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September 1966

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 7 July 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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TRITIUM IN SURFACE WATERS, 1964–1965

M. W. Chesnutt, J. C. Drobinski, Jr., and R. H. Gorrie [1]

SYNOPSIS—Concentrations of tritium in U.S. surface waters are reported for the period of May 1964 through December 1965. This is the initial report of a continuing surveillance program. The results show some differences in tritium concentrations in water samples from various parts of the country and as a function of time. The highest level observed (20.3 nCi/liter) is well below the occupational exposure guide (30 μCi/liter) and the guidance level requiring active surveillance (100 nCi/liter), calculated from the general guidance of the Federal Radiation Council.

Tritium occurs naturally in the environment as a product of cosmic ray bombardment of the upper atmosphere (*1–4*). Man has introduced tritium into the environment as a product of nuclear fusion (*5*), tritium manufacturing plants, and as a product of ternary fission in reactors (*6, 7*). Due to the relatively long half-life (12.26 years) of tritium and its potential radiological health implications, the Division of Radiological Health, Public Health Service, has established a modest surveillance program to determine concentrations of tritium in selected surface waters. This report presents the initial data from this program.

From the occupational exposure guide of 30 μCi/liter (*8, 9*) and using general guidance from the Federal Radiation Council (*10–12*), the concentration of tritium in water which requires active surveillance can be calculated to be 100 nCi liter.

PRELIMINARY STUDIES

During 1963, a preliminary study was conducted to determine the levels of tritium in raw and treated waters collected through the Water Pollution Surveillance Program of the Division of Water Supply and Pollution Control[2] and by the Institutional Total Diet Sampling Program of the Division of Radiological Health. Tritium levels were determined in additional samples collected upstream and downstream from the Atomic Energy Commission Savannah River Plant (*13*). Observed tritium concentrations in surface waters varied from less than detectable to 12 nCi/liter.

PRESENT PROGRAM

Sampling stations

Based on the preliminary findings and reports from other studies, a surveillance program was established in May 1964 to monitor tritium concentrations in major river systems in the contiguous United States. Ten stations were selected from existing water pollution

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[1] Mrs. Chesnutt (through June 1965) and Miss Gorrie are staff members of the Southeastern Radiological Health Laboratory, Division of Radiological Health, Box 61, Montgomery, Alabama. Mr. Drobinski is chief, Carbon-Tritium Section, Northeastern Radiological Health Laboratory, Division of Radiological Health, 109 Holton Street, Winchester, Massachusetts.

[2] In January 1966, this program was designated as the Basic Data Branch, Federal Water Pollution Control Administration, Department of the Interior.

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surveillance sampling stations in order to obtain coverage of major river basins. Eight of these stations are located downstream from nuclear facilities. Two stations serve to establish baseline levels (figure 1).

Analytical methods

Thirty-milliliter aliquots,[3] or greater, from 1-liter monthly composites of weekly samples collected from the water pollution surveillance stations are shipped to the Northeastern Radiological Health Laboratory (NERHL) or Southeastern Radiological Health Laboratory (SERHL) for analysis.

Both the NERHL and SERHL process samples in the liquid form using various adaptations of liquid scintillation counting techniques, and NERHL utilizes electrolysis cells to enrich the water in tritium.

At the NERHL, a sample is distilled to dryness from a slightly alkaline potassium permanganate solution. An aliquot of the distillate is concentrated approximately 25-fold by electrolysis (*14*). An aliquot of this enriched water is mixed with a scintillation mixture of p-dioxane, dimethoxyethane, naphthalene, 2, 5-diphenyloxazole, POP, (scintillation grade) and 1, 4-bis-2-(5-phenyloxazolyl)-benzene, POPOP, (scintillation grade) and counted in a liquid scintillation counter. The minimum level of detectability is approximately 0.1 nCi tritium/liter for a 100-minute count.

At the SERHL, a sample is distilled to dryness and an aliquot of the distillate is mixed with a scintillation mixture of p-dioxane, naphthalene, 2, 5-diphenyloxazole (scintillation grade) and 1, 4-bis-2-(5-phenyloxazolyl)-benzene (scintillation grade). The sample is then counted in a liquid scintillation counter (*15*). The minimum level of detectability is approximately 1.2 nCi tritium/liter for a 240-minute count.

The sensitivity of these methods is considered adequate for environmental surveillance purposes in relation to the calculated guidance level.

Results and discussion

Results of the analyses of the 1964 and 1965 surveillance program water samples are presented in table 1. The samples from Georgia, Tennessee, Ohio, and Pasco, Washington, were analyzed at the SERHL and samples from

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[3] NERHL received 500-ml portions.

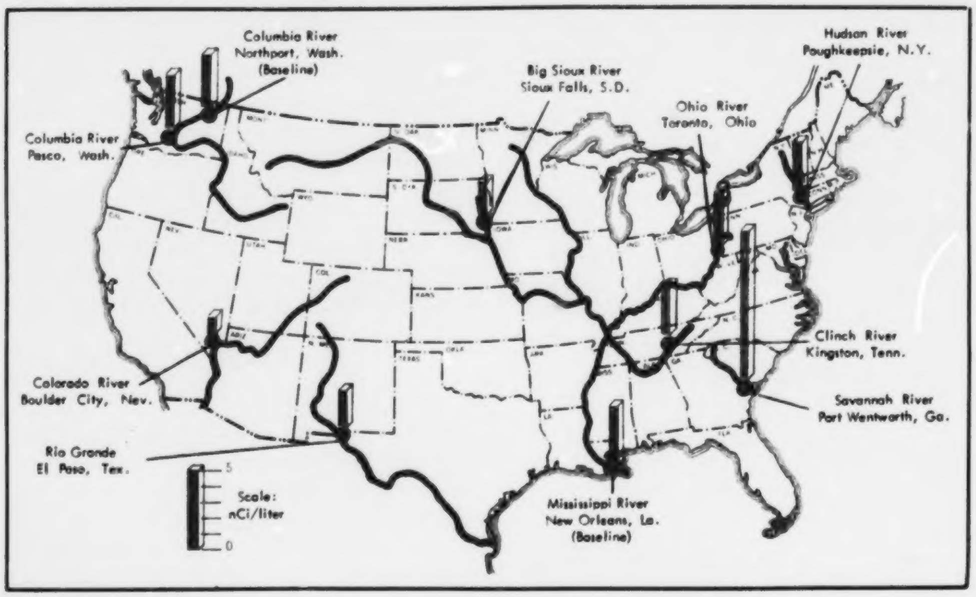
Columbia River
Northport, Wash.
(Baseline)
Big Sioux River
Sioux Falls, S.D.
Hudson River
Poughkeepsie, N.Y.
Ohio River
Toronto, Ohio
Columbia River
Pasco, Wash.
Clinch River
Kingston, Tenn.
Colorado River
Boulder City, Nev.
Savannah River
Port Wentworth, Ga.
Rio Grande
El Paso, Tex.
5
Scale:
nCi/liter
0
Mississippi River
New Orleans, La.
(Baseline)

Figure 1. Sampling stations for the Tritium Surveillance Program

Table 1. Tritium in surface waters from 10 sampling locations in the United States

Composite collection date	Tritium concentrations, nCi/liter [a]									
	Big Sioux River: Sioux Falls South Dakota	Clinch River: Kingston Tennessee	Colorado River: Boulder City Nevada	Columbia River: Northport Washington [c]	Columbia River: Pasco Washington	Hudson River: Poughkeepsie New York	Mississippi River: New Orleans Louisiana [c]	Ohio River: Toronto Ohio	Rio Grande: El Paso Texas	Savannah River: Port Wentworth Georgia
1964										
May	4.0±0.4	3.7±2.1	1.7±0.8	1.9±0.7	2.9±2.1	2.2±1.1	2.3±2.0	4.3±2.2	[b] 1.9±2.1	4.1±2.1
June	2.6±0.7	3.2±2.1	1.2±0.9	2.2±1.1	1.4±2.0	3.1±1.2	2.3±2.0	4.4±2.1	3.7±2.1	20.3±2.4
July	3.6±0.9	2.8±2.2	1.3±0.5	3.6±0.7	5.2±0.2	NS	3.4±2.1	2.8±2.1	3.8±2.1	8.1±2.2
August	2.6±0.6	[b] 2.0±2.0	[b] 0.5±0.9	5.8±0.8	2.3±2.0	5.0±0.9	[b] 0.8±1.9	[b] 1.4±2.1	2.7±2.0	6.9±2.1
September	2.5±0.6	2.9±1.9	0.6±0.4	4.0±0.6	6.0±1.9	3.3±0.9	[b] 0.9±1.9	3.8±1.9	[b] 0.8±1.8	6.8±1.9
October	1.3±0.5	6.7±1.9	1.2±0.7	3.6±0.3	3.9±1.9	3.7±0.5	[b] 1.8±2.0	2.4±1.9	[b] 1.1±1.8	9.0±2.0
November	1.0±0.3	4.3±1.8	1.2±0.4	3.4±0.5	4.3±1.8	3.2±0.4	[b] 0.7±1.6	4.0±1.8	[b] 0.8±1.7	4.3±1.8
December	[b] 0±2.8	[b] 1.2±1.7	1.0±0.4	2.6±0.5	3.1±1.8	3.0±0.2	[b] 0.7±1.6	1.8±1.7	[b] 1.0±1.7	3.1±1.8
1965										
January	1.4±0.5	1.9±1.7	1.4±0.6	[b] 0±3.9	7.5±1.8	1.6±0.4	[b] 1.6±1.8	[b] 1.7±1.8	2.6±1.7	4.3±1.8
February	[b] 0±3.6	2.0±0.9	[b] 0±3.6	[b] 2.6±3.6	2.5±0.8	[b] 1.1±3.6	1.2±0.9	2.4±0.9	[b] 0.4±0.9	5.1±0.9
March	[b] 0±3.9	6.5±1.8	[b] 0±3.9	[b] 0.1±3.9	5.1±1.7	[b] 0±3.9	3.6±1.7	3.2±1.8	2.8±1.7	9.5±1.8
April	[b] 2.7±3.8	3.0±1.8	[b] 0±3.4	[b] 2.6±3.6	5.0±1.8	[b] 3.3±3.4	5.0±1.8	4.1±2.0	2.9±1.8	8.3±1.8
May	[b] 0.8±3.9	NS	[b] 2.5±3.6	[b] 2.9±3.6	3.3±2.4	[b] 1.7±3.4	3.6±2.4	3.6±2.4	[b] 1.0±2.4	9.1±2.5
June	1.8±1.1	2.4±1.3	[b] 2.3±3.0	1.2±0.9	3.0±1.3	[b] 2.6±3.0	1.6±1.3	[b] 3.0±1.3	[b] 1.2±1.2	4.8±1.3
July	[b] 0.8±1.4	2.7±1.1	1.5±1.4	4.6±1.4	3.3±1.0	3.6±1.4	[b] 0.8±1.0	NS	[b] 0.5±1.0	10.8±1.2
August	[b] 0.4±1.3	[b] 1.0±1.4	[b] 0.7±1.9	2.5±1.4	[b] 0.3±1.3	3.0±1.4	[b] 0.5±1.5	1.7±1.4	2.4±1.4	6.7±1.1
September	4.7±1.5	5.7±1.5	4.1±1.5	7.9±1.5	4.0±1.5	3.8±1.5	2.3±1.5	8.1±1.5	4.2±1.5	9.6±1.5
October	2.0±1.5	1.9±1.6	3.0±1.6	1.9±1.5	3.1±1.5	3.0±1.6	[b] 0.9±1.5	1.6±1.5	[b] 1.2±1.2	17.1±1.7
November	[b] 0.7±2.2	[b] 0.7±1.7	2.7±1.8	3.0±1.6	[b] 1.4±1.8	[b] 0.9±1.9	[b] 0.5±2.0	[b] 0.8±1.8	[b] 0±2.0	12.2±2.0
December	3.0±2.1	[b] 1.4±1.7	2.3±2.0	[b] 1.4±2.6	6.1±2.1	3.2±1.9	[b] 0.5±2.1	2.0±2.2	0±2.0	14.0±2.2

[a] The error reported is the counting error at 95 percent confidence level.
[b] Values are not statistically significant at 95 percent confidence level.
[c] Baseline station.
NS, no sample

Nevada, New York, South Dakota, and Northport, Washington, were analyzed at the NERHL during May 1964–June 1965. From July to December 1965, all samples were analyzed at the SERHL. For quality control purposes, aliquots of the monthly samples collected during the period of May 1964–June 1965 from El Paso, Texas, and New Orleans, Louisiana, were analyzed by both laboratories.

Differences in tritium content among the sampling stations were anticipated, based on previously reported geographical and meteorological variations in natural tritium levels (*4*). These differences are shown in figure 2. The highest concentration observed for 1 month was 20.3 nCi/liter, which is well below the occupational exposure guide (30 μCi/liter) and the guidance level requiring active surveillance (100 nCi/liter), calculated from the general guidance of the Federal Radiation Council. Although the concentrations observed at the stations vary significantly, there is no indication that the water from stations downstream from nuclear facilities, with the single exception of Port Wentworth, Georgia, has higher levels of tritium than those observed at baseline stations.

Although the results of this program indicate that, at the present time, tritium levels in the environment do not suggest immediate public health implications, the Public Health Service is maintaining surveillance on a modest scale with provisions for an increased program if the need arises.

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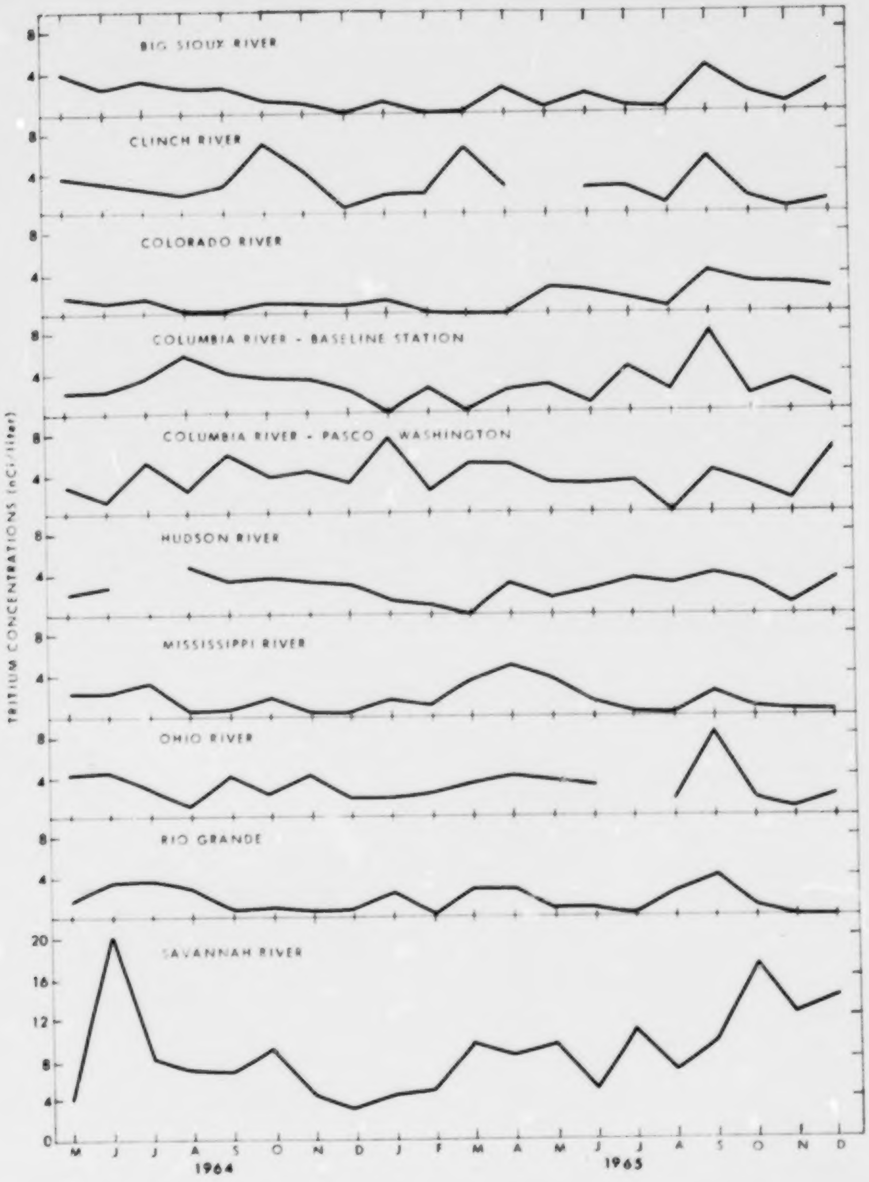

Figure 2. Tritium in surface waters from 10 U.S. sampling locations, 1964–1965

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STRONTIUM-90 IN 1965 UNITED STATES WHEAT

R. A. Anderson and *V. F. Pfeifer*[1]

SYNOPSIS—In continuing surveys of strontium-90 levels in wheat, USDA studies indicate the U.S. weighted average concentration to be 95 pCi/kg, which compares well with the Federal Radiation Council's prediction for 1965 (88 pCi/kg). The 1965 average also confirms the predicted continuing downward trend seen in 1963 and 1964 averages—220 and 133 pCi/kg, respectively. Samples used to develop the 1965 average represented 52 percent of the U.S. wheat production and individual strontium-90 concentrations ranged from a low of 31 pCi/kg, in a soft white winter wheat from Washington, to a high of 174 pCi/kg in hard red winter wheat from Kansas. It was noted that the 1965 trends of high and low concentrations were similar to those of 1964.

As part of studies on methods for reducing the strontium-90 content of wheat and milled products the USDA's Northern Regional Research Laboratory is continuing to survey strontium-90 levels in U.S. wheats from major producing areas. Strontium-90 levels reported for the 1963 and 1964 crops averaged 220 and 133 pCi/kg (dry basis) for the two respective crop years (*1*, *2*).

In general, samples from the 1965 harvest were representative mixes of varieties grown in 14 different locations in seven wheat-producing States. These areas represent about 52 percent of the total of 1965 wheat production (*3*). The analytical procedures used have been described previously (*2*).

The results listed in table 1 show lowest levels of strontium-90 in wheat from Washington and North Dakota, and the highest from Kansas and Nebraska. Individual values range from a low of 31 pCi/kg (dry basis) for soft white winter wheat grown in Washington, to a high of 174 for a hard red winter wheat mix grown on dry land in Garden City, Kansas. In 1964, the high and low levels of strontium-90 occurred in wheat from these same areas. Furthermore, Ottawa variety of hard red winter wheat had the highest strontium-90 content in 1964, 380 pCi/kg (dry basis); and this high level continued in 1965; a sample of Ottawa wheat harvested in Douglas County, Kansas had strontium-90 content of 166 pCi/kg.

Although sampling in 1965 was not quite so complete as in 1964 with respect to areas covered, it is believed that it is adequate to permit a reasonable estimate to be made of average strontium-90 content in 1965 wheats. If State averages are estimated by averaging the corresponding local values (table 1), and if each State average is weighted according to the ratio of 1965 wheat production in that State to the total 1965 crop, the U.S. average is 95 pCi/kg (dry basis). This estimate compares well with the Federal Radiation Council's predicted average value of 88 pCi/kg (dry

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[1] Mr. Anderson and Mr. Pfeifer are chemical engineers at the Northern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture, located at Peoria, Illinois 61604.

Table 1. Analyses of U.S. wheats harvested in 1965 [a]

Wheat class	Grown in vicinity of	Number of samples	Nitrogen (percent)	Ash (percent)	Calcium (percent)	Strontium-90 (pCi/kg)
HRW [b]	Peoria, Ill	1	2.35	2.08	.054	84
HRW	Douglas County, Kans	1	2.80	2.00	.058	166
HRW	Newton, Kans	[f] Mix	2.44	1.94	.056	133
HRW	Manhattan, Kans	12	2.65	1.60	.044	82
HRW	Garden City, Kans. (Dry land)	Mix	3.01	2.16	.058	174
HRW	Garden City, Kans. (Irrigated)	Mix	2.97	2.17	.055	158
HRW	Hays, Kans	13	2.54	1.72	.049	157
HRW	Alliance, Nebr	Mix	1.92	1.85	.052	95
HRW	Lincoln, Nebr	Mix	2.63	2.04	.064	147
HRS [c]	Carrington, N. Dak	Mix	2.99	1.85	.033	53
HRS	Minot, N. Dak	Mix	2.63	1.90	.036	52
SRW [d]	Huntington, Ind	2	2.17	1.88	.047	98
SWW [e]	Breckenridge, Mich	1	2.17	1.49	.042	82
SWW	Pullman, Wash	6	1.29	1.38	.048	31
SWW	Rosalia, Wash	1	2.31	1.87	.038	67

[a] Calculated on a dry basis where the wheat moisture contents varied from 9.4 to 12.7 percent.
[b] HRW indicates a hard red winter wheat.
[c] HRS indicates a hard red spring wheat.
[d] SRW indicates a soft red winter wheat.
[e] SWW indicates a soft white winter wheat.
[f] Representative mixture of an undisclosed number of different wheat varieties grown in immediate area.

basis) for 1965 U.S. wheat and confirms its prediction of a continuing downward trend in strontium-90 levels in wheat (*4*).

Acknowledgments

We acknowledge the cooperation of the following stations, firms, and individuals in supplying the samples of 1965 wheat: Agricultural Experiment Stations at Newton Manhattan, Garden City, and Hays, Kansas, and at Lincoln and Alliance, Nebraska; Western Wheat Quality Laboratory, Pullman, Washington; Loon Creek Valley Farms, Huntington, Indiana; B&W Cooperative, Breakenridge, Michigan; Rosalia Producers, Inc., Rosalia, Washington; Klindworth Seed and Supply, Carrington, North Dakota; Peavey Company, Minot, North Dakota; and J. E. Hubbard, Northern Laboratory, Peoria, Illinois.

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STRONTIUM-90 IN HUMAN BONE FROM INFANCY TO ADULTHOOD 1962–1963

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and *Edmond J. Baratta* [2]

SYNOPSIS—Strontium–90 accumulation in the bones of children and adults through age 25 is analyzed by comparing the strontium–90 to calcium ratios found in specimens from selected age groups during the 1962–1963 portion of a continuing program. The highest mean strontium–90 to calcium ratios were found in the 1- to 4-year olds, with the 1962 peak in the 1-year olds (4.5 pCi/g) and the 1963 peak in the 2-year olds (5.6 pCi/g). It is pointed out that the mean values for the group under 1 year of age were relatively low (2.6 pCi/g in 1962; 1.8 pCi/g in 1963), but were obtained from a small number of samples. Average strontium–90 to calcium ratios in bone of older groups declined with increasing age and were least in the 20- to 25-year-age group. The data for each age group, although limited, appear to follow a log normal distribution, and it is suggested that this distribution is more suitable than a normal distribution as a basis for calculating the proportion of a population group in which a given body burden is unlikely to be exceeded.

The Public Health Service's Division of Radiological Health and cooperating institutions continue to gain information on the accumulation of selected radionuclides in people based on direct measurements in human organs and tissues (*1*). A previous report included results from the strontium–90 in human bone program through June 1964; it analyzed the data available at that time from 322 individuals who died in 1962 or 1963 (*2*). Subsequently, the results of 117 specimens and replicate measurements of previous samples were reported (*3, 4*). This report is an analysis of the information on a total of 439 individuals who died in 1962 and 1963 at an age of not more than 25 years.

Materials and methods

The program employs sampling procedures designed to exclude bone samples from individuals manifesting certain nutritional deficiencies or disorders of calcium metabolism. Laboratory procedures have been described in a previous report (*5*).

Results

The data on strontium–90 to calcium ratios are summarized in 1-year-age groups for ages through 4 years, and in four age ranges for specimens between 5 and 25 years of age at death. The number of individuals in each age category, the median and mean strontium–90 to calcium ratios in bone, and the standard error of the mean for each age group are shown in table 1.

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Table 1. Strontium-90/calcium ratios in human bone samples from selected deaths in the United States in 1962–1963

Age group (years)	1962 Ratios, pCi/g				1963 Ratios, pCi/g			
	Number of samples	Median	Mean	S.E.*	Number of samples	Median	Mean	S.E.*
<1	15	1.9	2.6	0.46	5	1.3	1.8	0.45
1	9	3.7	4.5	0.90	4	4.2	4.7	1.09
2	11	2.9	3.9	0.58	9	5.2	5 6	0.95
3	5	3.2	3.1	0.33	11	4.8	5.3	0.70
4	10	2.5	2.6	0.24	15	3.9	4.1	0.41
1–3	25	3.2	3.9	0.42	24	4.8	5.3	0.51
1–4	35	3.0	3.6	0.32	39	4.1	4.8	0.38
5–9	33	2.3	2.7	0.32	43	3.7	3.9	0.22
10–14	28	2.0	2.1	0.18	47	2.6	2.9	0.20
15–19	31	2.0	2.2	0.15	73	2.5	2.6	0.11
20–25	29	1.8	1.8	0.13	61	2.1	2.2	0.10
All ages	171				268			

* One standard error of the mean.

Data in figure 1 and table 1 suggest that a "peak" value for strontium–90 to calcium in the bone samples from deaths in 1963 probably occurred in the 2-year-age group. The mean value for this group was 5.6 pCi/g, which may be compared with 1.8 for the <1-year group and 2.2 for the 20- to 25-year group. The "peak" mean strontium–90 to calcium for bone from 1962 deaths (4.5 pCi/g) occurred in the 1-year-old group; the corresponding value in the 2-year-old group was 3.9 pCi/g. The number of samples in each of the 12-month categories was small, however, and the "peaks" for both 1962 and 1963 may actually have spanned more than 1 year of age. The latter view appears consistent with the observation from table 2 that the 1962 mean and median strontium–90 to calcium ratios are similar for the 1-, 2-, and 3-year-old groups, and somewhat less for the 4-year-old group. For children in the 1- to 4-year-age range in 1962, the strontium–90 to calcium ratio was 1.7 to 2.0 times that observed in the adult group. A similar relationship was observed in the strontium–90 to calcium ratios for 1963, except that the changes with age were more gradual. For 1963 the greatest mean and median strontium–90 to calcium ratios occur in the 2-year-old group. The average strontium–90 to calcium ratio for the 1-year through the 5- to 9-year-old groups was about twice that found in the 20- to 25-year-old group. The observations seem consistent with the contention that the "peak"

Table 2. Ratio of strontium-90 to calcium in bone for various age groups to the strontium-90 to calcium in bone for the age group 20 to 25 years

Age group (years)	Ratio, 1962		Ratio, 1963	
	From median	From mean	From median	From mean
<1	1.0	1.5	0.6	0.8
1	2.1	2.5	2.0	2.1
2	1.6	2.2	2.5	2.6
3	1.8	1.7	2.3	2.4
4	1.4	1.4	1.9	1.9
1–4	1.7	2.0	2.0	2.2
5–9	1.3	1.5	1.9	1.8
10–14	1.1	1.2	1.2	1.3
15–19	1.2	1.1	1.2	1.2
20–25	1.0	1.0	1.0	1.0

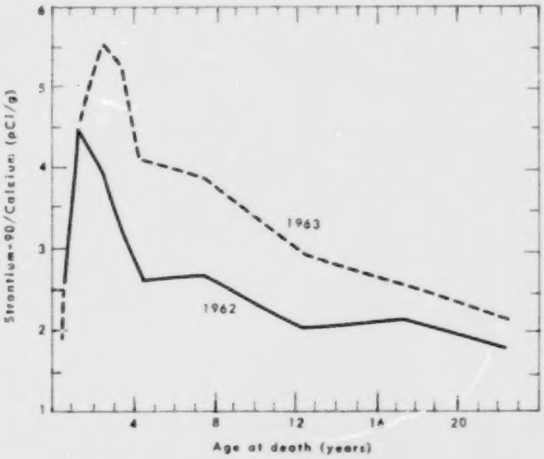

Figure 1. Mean strontium-90 to calcium ratios in samples of human bone from individuals who died in the United States in 1962 and 1963

strontium–90 to calcium in bone will gradually move through increasingly older age groups up to adulthood provided that the strontium–90 to calcium ratio in the diet remains constant or decreases from concentrations existing in 1963.

Attention was called to the skewness in the distribution of strontium–90 to calcium in bone, which was skewed due to a relatively small number of high values (*2*). It was further shown that the plotting on log probability paper of strontium–90 to calcium in bone for each age group in 1963 data (table 1) produced a straight-line fit, characteristic of a log normal distribution (figure 2). To the extent that the bone sampling reflects the distribution of strontium–90 in population groups, the number of individuals whose body burdens might exceed a given value might thus be underestimated if a normal distribution is assumed. As a basis for the calculation of the proportion of a population group in which a given burden is unlikely to be exceeded, assumption of a log normal distribution appears preferable to that of a normal distribution. All of the strontium–90 to calcium data for deaths in 1963 only were used in figure 2.

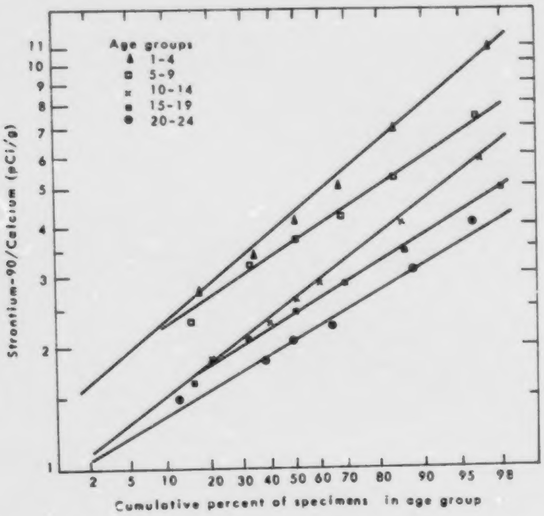

Figure 2. Log-probability plots of strontium–90 to calcium ratios in samples of human bone from individuals who died in the United States in 1963

In table 3, the 95th or 98th percentile value for strontium–90 to calcium in bone for each age group for 1963 was divided by the median (50th percentile value) for the group. Such ratios and the 50th percentile values may be used to calculate the strontium–90 to calcium values in bone for a specified percentage of individuals in a population group. For example, for 1963 and for individuals in the 1- to 19-year-age group at or above the 95th percentile, the strontium–90 to calcium may be calculated to be ≥3.3 x 1.9; *i.e.*, 6.3 pCi/g or more.

Table 3. Comparison of the 95th and 98th percentile strontium-90 to calcium values with the median (50th percentile) in bone from various selected ages at death in the United States in 1963

Age group (years)	Median value strontium-90/ calcium (pCi/g)	Ratio of the 95-percent to median value	Ratio of the 98-percent to median value
1–4	4.3	2.1	2.6
5–9	3.6	1.9	2.2
10–14	2.7	2.0	2.4
15–19	2.5	1.7	2.0
20–25	2.[illegible]	1.7	2.0
1–19	[a] 3.3	1.9	2.3

[a] Average of four groups

Discussion

The results given in table 1 and figure 1 suggest that the bone burden of strontium–90 in the age group less than 1 year may be substantially less than the bone burden for age groups 1-4, 5-9, 10-14, and 15-19 in a decreasing order, for both 1962 and 1963. The <1-year group did not include specimens from stillbirths. It is postulated, however, that the strontium–90 to calcium in stillbirth specimens would be substantially lower than that of specimens in the 1-4-year group and, hence, data on stillbirth specimens, which may be collected with relative ease, must be interpreted with extreme care if used to predict bone burdens of strontium–90 in children.

Assuming a linear proportionality of 1 nCi strontium–90/g bone calcium being equivalent to a yearly dose of 0.9 rads (*6*), then the maximum dose for 98 percent of the individuals in the age group of 1 to 4 years would be (from table 3) 4.3 x 2.6 x 0.9, or 10 millirads per year, as compared to the Radiation Protection Guide (*6*) of 170 millirads/year.

Summary

The bone samples, which totaled 171 for 1962 and 268 for 1963, were arranged into six major and four minor age categories from less than 1 year to the adult group of 20 to 25 years of age.

In a rather limited number of samples available in the 12-month categories less than 5 years of age, the mean strontium–90 to calcium ratio was highest in the 1-year group in 1962 (4.5 pCi/g) and in the 2-year group in 1963 (5.5 pCi/g).

The average strontium–90 to calcium in bone of older groups decreased progressively (slope decreasing with increasing age) and was least in the adults of the 20- to 25-year group (1.9 pCi/g in 1962 and 2.2 pCi/g in 1963). The mean strontium–90 to calcium for the small number of samples in the youngest age group (<1 year) was only 2.4 pCi/g for 1962 and 1.8 pCi/g for 1963.

The data definitely suggest that interest in strontium–90 in human bone, for 1962 and 1963 at least, should be directed to the 1- to 4-year-age group. It is emphasized that the low values in the <1-year group, when combined with the 1- to 4-year-old group, may result in underestimating burdens in the latter range.

The data, although limited, appear to be characteristic of a log normal distribution in each age group. To the extent that the bone sampling reflects the distribution of strontium–90 in population groups, the number of individuals whose body burden might exceed a given value might thus be underestimated if a normal distribution is assumed. As a basis for the calculation of the proportion of a population group in which a given burden is unlikely to be exceeded, the assumption of log normal distribution appears preferable to that of a normal distribution.

Acknowledgement

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Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of shortlived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionucides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by FRC Protective Action Guides (*4*) and the International Commission on Radiological Protection (*5, 6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to assess man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in Milk, HASL	July–December 1965	June 1966
United Kingdom Milk	1962–1965	June 1966

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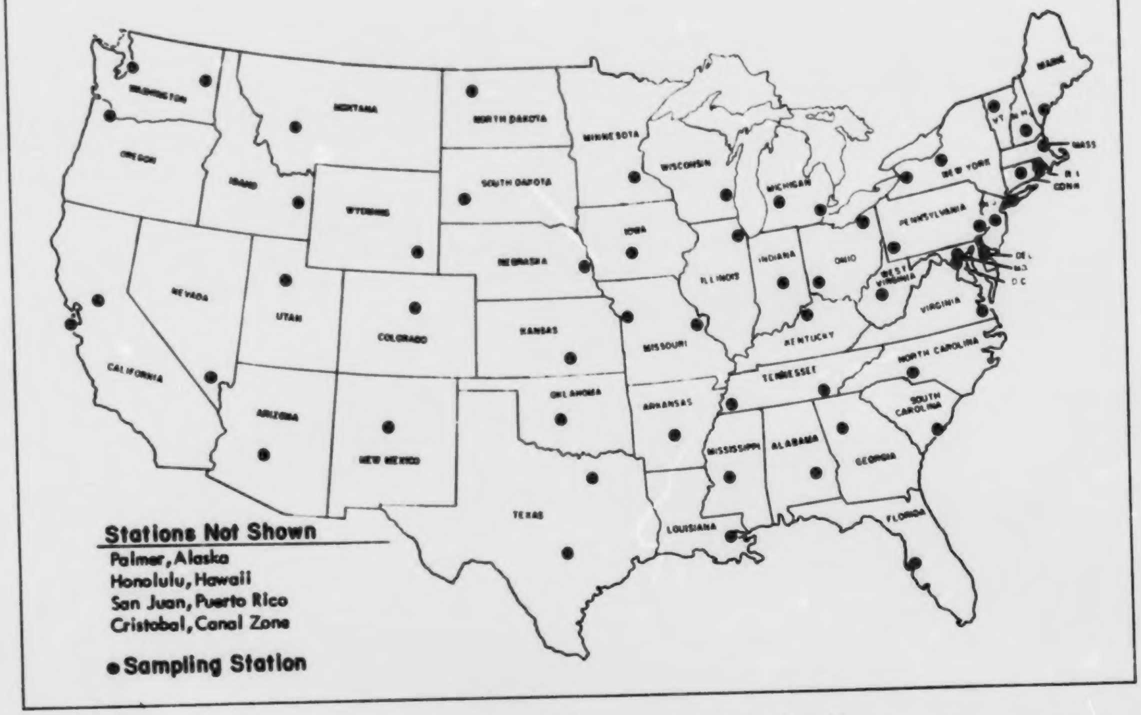
1. Pasteurized Milk Network
March 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN), was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling of major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).


WASHINGTON
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CALIFORNIA
IDAHO
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MONTANA
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SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VT
N.H.
MAINE
MASS
R.I.
CONN
DEL
MD
D.C.
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the first quarter and March 1966 [a]

Sampling location		Calcium (g/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		First quarter 1966	March 1966	First quarter 1966	March 1966	First quarter 1966	March 1966
Ala:	Montgomery	1.17	1.11	12	13	25	20
Alaska:	Palmer	1.24	1.22	14	14	40	35
Ariz:	Phoenix	1.23	1.20	4	4	15	10
Ark:	Little Rock	1.17	1.14	26	30	40	35
Calif:	Sacramento	1.26	1.22	6	6	15	20
	San Francisco	1.24	1.24	7	8	20	20
C. Z:	Cristobal	1.12	1.12	4	5	25	20
Colo:	Denver	1.25	1.20	11	10	25	30
Conn:	Hartford	1.14	1.15	11	11	40	40
Del:	Wilmington	1.18	1.16	13	13	40	40
D. C:	Washington	1.15	1.14	12	12	30	25
Fla:	Tampa	1.17	1.16	11	10	105	100
Ga:	Atlanta	1.15	1.15	19	21	40	45
Hawaii:	Honolulu	1.17	1.17	5	5	35	30
Idaho:	Idaho Falls	1.25	1.22	13	14	40	45
Ill:	Chicago	1.12	1.11	11	11	35	40
Ind:	Indianapolis	1.18	1.16	12	11	30	30
Iowa:	Des Moines	1.24	1.23	14	13	30	40
Kans:	Wichita	1.26	1.21	13	13	20	20
Ky:	Louisville	1.16	1.14	16	18	25	20
La:	New Orleans	1.21	1.19	29	30	40	40
Maine:	Portland	1.15	1.14	15	16	65	70
Md:	Baltimore	1.15	1.15	13	13	30	30
Mass:	Boston	1.16	1.16	14	13	60	60
Mich:	Detroit	1.14	1.15	11	12	35	35
	Grand Rapids	1.19	1.17	14	14	45	45
Minn:	Minneapolis	1.24	1.23	20	21	40	35
Miss:	Jackson	1.24	1.21	23	26	25	25
Mo:	Kansas City	1.22	1.19	15	15	20	20
	St. Louis	1.21	1.23	15	15	30	35
Mont:	Helena	1.25	1.20	15	16	60	60
Nebr:	Omaha	1.24	1.23	15	15	25	30
Nev:	Las Vegas	1.23	1.19	7	5	20	20
N. H:	Manchester	1.17	1.16	18	18	75	75
N. J:	Trenton	1.15	1.13	12	11	40	35
N. Mex:	Albuquerque	1.24	1.20	6	6	15	15
N. Y:	Buffalo	1.12	1.10	10	12	40	40
	New York	1.11	1.11	13	13	45	45
	Syracuse	1.13	1.13	10	11	40	40
N. C:	Charlotte	1.17	1.12	20	21	30	30
N. Dak	Minot	1.24	1.21	31	32	45	40
Ohio:	Cincinnati	1.16	1.16	12	11	25	30
	Cleveland	1.16	1.14	13	14	35	35
Okla:	Oklahoma City	1.15	1.14	13	14	25	25
Ore:	Portland	1.24	1.19	12	11	35	30
Pa:	Philadelphia	1.15	1.14	12	12	35	35
	Pittsburgh	1.17	1.16	17	17	45	45
P. R:	San Juan	1.12	1.10	8	9	25	20
R. I:	Providence	1.15	1.14	12	12	45	45
S. C:	Charleston	1.19	1.17	23	23	45	40
S. Dak:	Rapid City	1.15	1.21	19	21	45	45
Tenn:	Chattanooga	1.21	1.23	21	22	25	25
	Memphis	1.19	1.20	17	17	15	10
Tex:	Austin	1.15	1.13	6	6	15	10
	Dallas	1.18	1.16	14	14	20	20
Utah:	Salt Lake City	1.31	1.26	13	13	40	40
Vt:	Burlington	1.15	1.13	14	13	55	55
Va:	Norfolk	1.16	1.14	16	16	25	25
Wash:	Seattle	1.24	1.21	15	15	40	45
	Spokane	1.32	1.33	15	16	40	50
W. Va:	Charleston	1.15	1.16	14	15	25	20
Wis:	Milwaukee	1.20	1.19	11	11	40	40
Wyo:	Laramie	1.21	1.21	14	11	30	25
Network average		1.19	1.17	13.8	14.1	35	35

[a] Strontium-89 concentrations were all less than detectable level of 5 pCi/liter.

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Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, March 1966 and October 1965–March 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965				1966		
	Mar	Oct	Nov	Dec	Jan	Feb	Mar
Under 10	5	8	9	9	10	9	9
10–19	29	46	43	43	46	46	44
20–29	21	7	9	11	6	7	7
30–39	6	2	2	0	1	1	3
40–49	1	0	0	0	0	0	0
50–59	1	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, March 1966 and October 1965–March 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965				1966		
	Mar	Oct	Nov	Dec	Jan	Feb	Mar
Under 50	9	54	57	51	57	56	56
50–99	36	8	5	11	5	6	6
100–149	16	0	1	1	1	1	1
150–199	2	1	0	0	0	0	0

The monthly averages for March 1966 and the first quarter averages for 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values are below minimum detectable concentrations (*1*), averages are calculated using one-half the minimum detectable value.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for March 1965 and October 1965 through March 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2. During March 1966, the monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

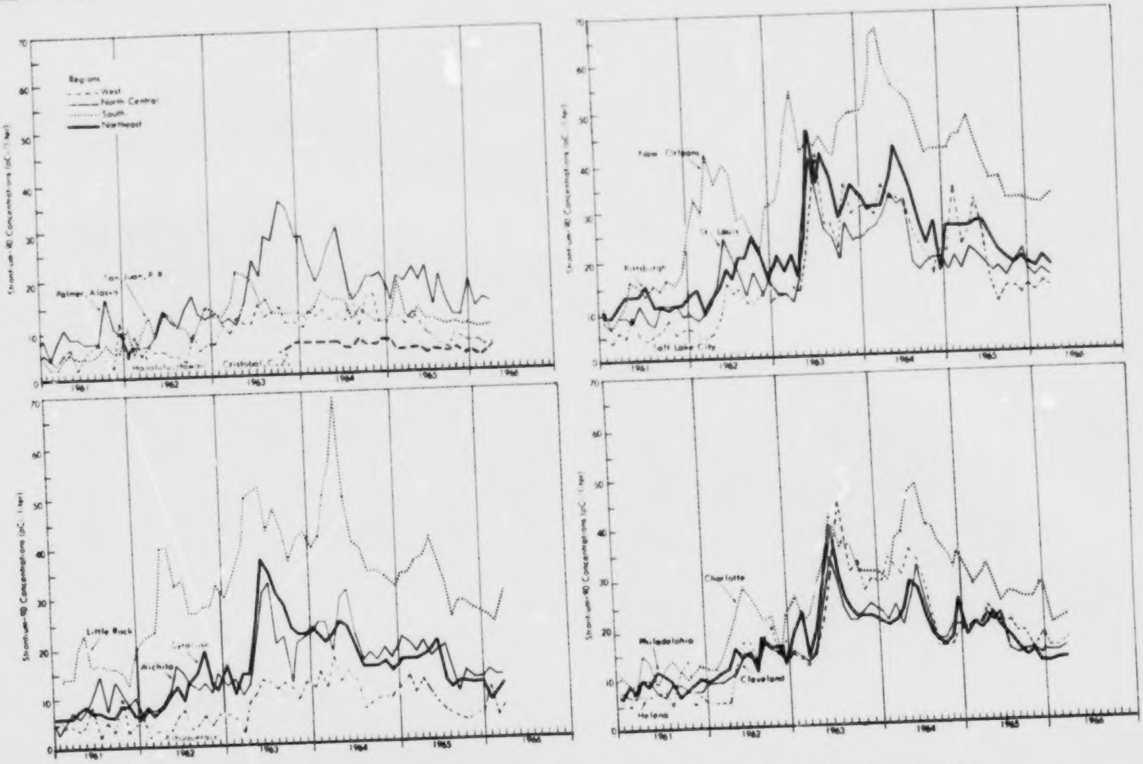

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961—March 1966

2. Canadian Milk Network
March 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, stable calcium, and stable potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (2).

The March 1966 monthly averages for strontium–90, cesium–137, stable calcium, and stable potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels during the period covered by this report.

Table 4. Stable elements and radionuclides in Canadian whole milk, March 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.12	1.4	20.7	71
Edmonton	1.10	1.5	19.1	55
Ft. William	1.10	1.6	27.9	43
Fredericton	1.12	1.6	29.3	76
Halifax	1.13	1.6	25.5	69
Montreal	1.08	1.6	17.7	50
Ottawa	1.15	1.4	14.1	40
Quebec	1.09	1.6	28.0	89
Regina	1.12	1.5	17.6	39
St. John's, Nfld	1.08	1.6	23.3	88
Saskatoon	1.14	1.6	21.6	38
Sault Ste. Marie	1.11	1.6	26.8	72
Toronto	1.15	1.7	10.6	29
Vancouver	1.16	1.6	22.0	80
Windsor	1.12	1.6	11.3	33
Winnipeg	1.09	1.6	20.9	60
Average	1.12	1.6	21.0	62

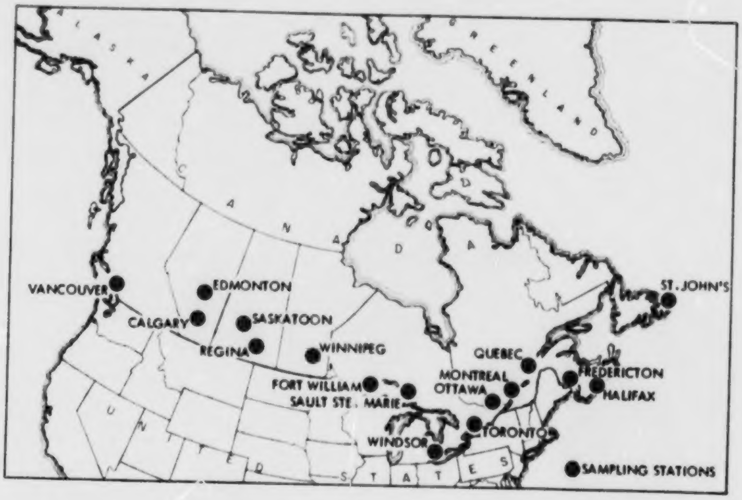

Figure 3. Canadian milk sampling stations

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[1] Prepared from April 1966 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program March 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Information on the sampling and analytical procedures employed appeared in the December 1965 issue of *Radiological Health Data* (*3*).

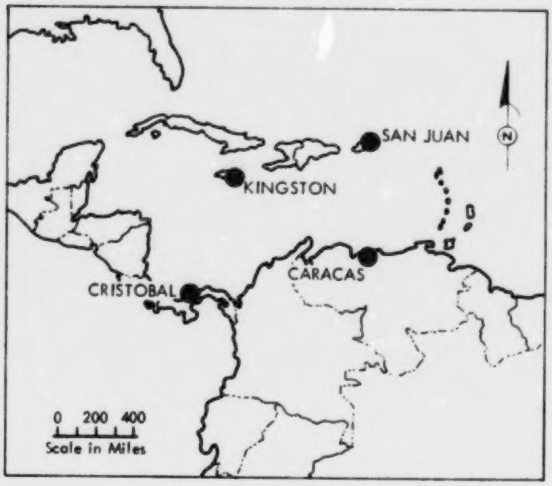

Figure 4. Pan American Milk Network sampling locations

Table 5 presents stable calcium and potassium, strontium-90, strontium-89 and cesium-137 monthly average concentrations for March 1966. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter for the period covered by this report.

Correction

There was an error in reporting the data for Caracas, Venezuela, in the June *Radiological Health Data and Reports;* the corrected values for February 1966 have been added to table 5.

Table 5. PAHO stable element and radionuclide concentrations in milk, March 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.12	1.4	<5	5	20
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.25	1.4	<5	14	360
Puerto Rico:					
San Juan	1.10	1.4	<5	9	20
Venezuela:					
Caracas					
(Feb 1966) [a]	1.10	1.38	<5	4	20
(Mar 1966)	NS	NS	NS	NS	NS

NS, no sample collected.
[a] Corrected data for February 1966.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

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STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein, while not inclusive, are representative of current surveillance activities directed toward the use of milk as an indication of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

Milk network	Period reported	Last presented
California	October–December 1965	June 1966
Colorado	October–December 1964	April 1965
Connecticut	October–December 1965	May 1966
Indiana	October–December 1965	May 1966
Michigan	October–December 1965	May 1966
Minnesota	July–December 1965	May 1966
New York	July–December 1965	May 1966
Oregon	October–December 1965	June 1966
Pennsylvania	October–December 1965	May 1966
Washington	October–December 1965	June 1966

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1. Florida Milk Network
January–March 1966

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, and cesium–137. Raw milk samples are received from the six areas shown in figure 1. Monthly samples are taken from randomly selected farms in the areas represented. A regional State Board of Health laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are now collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are charac-

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terized by differences in dairying practices related to the gradual transition from small farms in the West Florida region, where locally grown feeds are used, to larger farms in the Southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium-89 and strontium-90 are determined by the ion exchange method developed by Porter, *et al.* (*1*). Iodine-131 and cesium-137 are determined by gamma scintillation spectrometry (*2*).

Radionuclide concentration levels for January through March 1966 are presented in tables 1 and 2. During this period, iodine-131 concentrations remained below the minimum detectable level of 10 pCi/liter. Strontium-89 analyses have been discontinued due to extremely low levels during 1965.

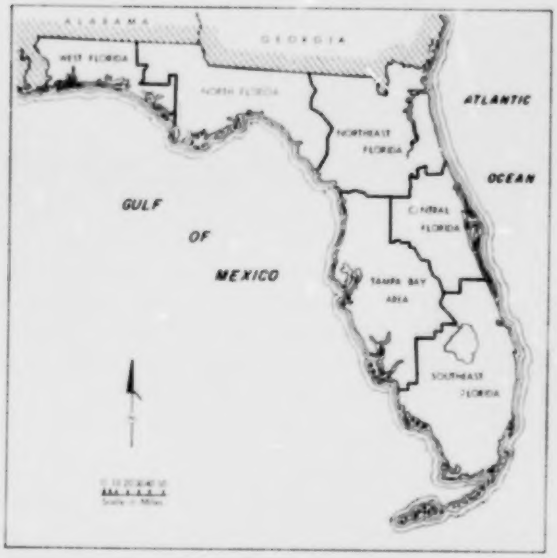

Figure 1. Florida milk sampling areas

Table 1. Strontium-90 in Florida raw milk January–March 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay Area	Southeast Florida	Average
January—February	[a] 25.9	[a] 25.7	[a] 12.6	NA	[a] 12.3	[a] 10.0	[a] 17.3
March	28.5	24.2	11.9	NA	10.9	10.4	17.1
Average	27.2	24.9	12.2		11.6	10.2	17.2

[a] Composite for January and February.
NA, no analysis due to insufficient sample volume.

Table 2. Cesium-137 in Florida raw milk January–March 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay Area	Southeast Florida	Average
January	33	54	120	NA	104	134	89.0
February	37	71	107	NA	142	119	95.2
March	32	57	117	NA	122	116	88.8
Average	34.0	60.7	114.7		122.7	123.0	91.0

NA, no analysis due to insufficient sample volume.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1964	November 1965
January–June 1965	January 1966
July–December 1965	April 1966

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2. Oklahoma Milk Network
January–March 1966

Oklahoma State Department of Health[1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine-131 in milk produced in the State.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 2. Of the ten milksheds in the State, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine-131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 2, it is considered satisfactory for surveillance purposes.

At the present time, samples are collected each Monday morning and the analyses are completed by Wednesday afternoon. However, if iodine-131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about four hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The ion exchange method of analysis used is similar to that recently published by the Public Health Service (*3*), but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory. Details of the procedure used were presented earlier (*4*).

Iodine-131 concentrations in Oklahoma milk for the period of January through March 1966 were below the detectable level of 0.9 pCi/liter.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
March–July 1965	October 1965
August–December 1965	April 1966

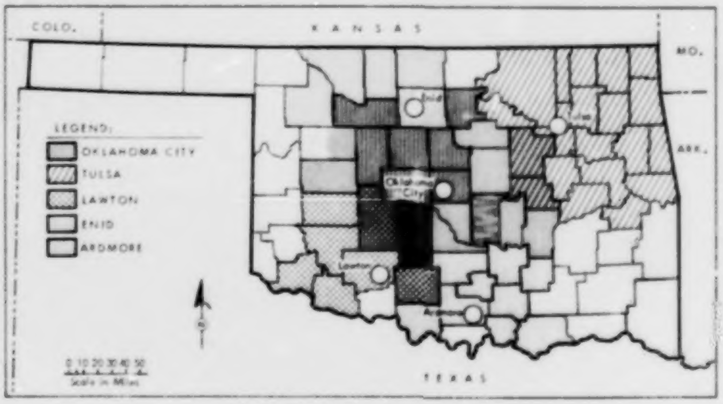

Figure 2. Oklahoma milkshed sampling areas

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[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert L. Craig, assistant engineer.

3. Texas Milk Network
January-March 1966

Texas State Department of Health[2]

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "stand-by" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "stand-by" station locations, shown in figure 3, were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium-89 and strontium-90 by chemical separation technique employing ion exchange columns (*5*).

Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectrometry. Details of the analytical procedures were presented earlier (*6*).

Table 3 presents the January through March 1966 radionuclide concentrations in Texas milk. During this time, strontium-89, iodine-131, and barium 140 concentrations were below detectable levels. Strontium-90 and cesium-137 concentrations are shown graphically in figure 4 to indicate general trends.

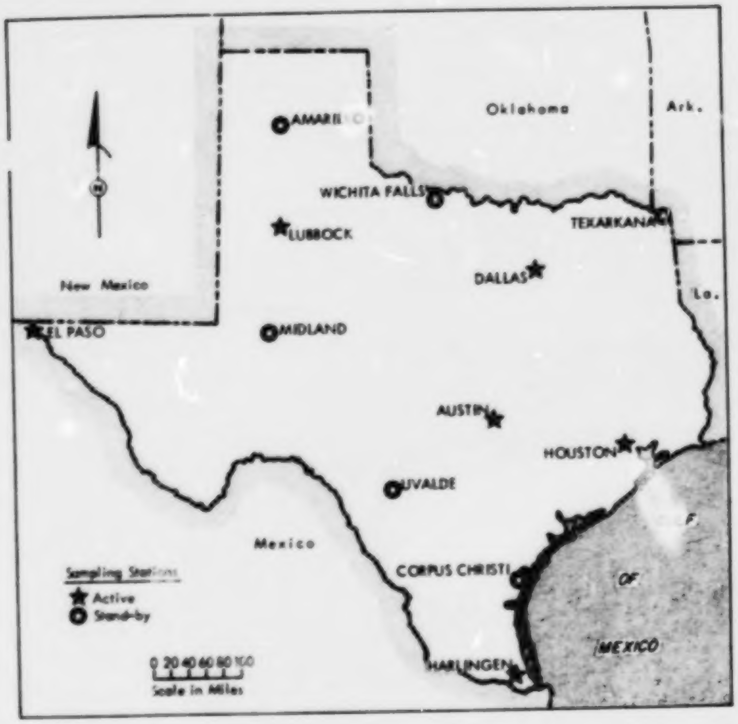
N
New Mexico
Oklahoma
Ark.
La.
AMARILLO
WICHITA FALLS
LUBBOCK
TEXARKANA
DALLAS
EL PASO
MIDLAND
AUSTIN
HOUSTON
UVALDE
Mexico
CORPUS CHRISTI
HARLINGEN
GULF
OF
MEXICO
Sampling Stations
Active
Stand-by
0 20 40 60 80 100
Scale in Miles

Figure 3. Texas milk sampling stations

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[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

Table 3. Radionuclide concentrations in Texas milk network, January–March 1966

Sampling location	Potassium-40, pCi/liter			Strontium-90, pCi/liter			Cesium-137, pCi/liter		
	January	February	March	January	February	March	January	February	March
Austin	1,280	NS	1,270	10	NS	5	30	NS	5
Dallas	1,350	NS	NS	11	NS	NS	20	NS	NS
El Paso	1,280	1,120	1,290	8	9	5	10	10	5
Harlingen	1,290	1,330	1,230	10	5	8	10	15	20
Houston	1,330	1,260	1,310	14	12	14	30	30	35
Lubbock	1,310	1,190	1,320	13	10	7	5	20	20
Average	1,307	1,250	1,284	11	9	8	17.5	18.8	17.0

NS, no sample collected

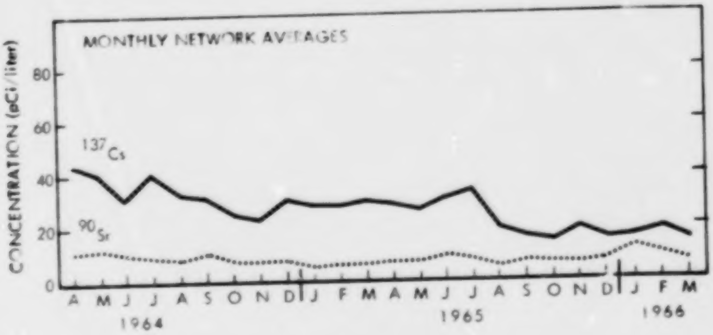

Figure 4. Radionuclide concentrations in Texas milk
April 1964—March 1966

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1964	June 1965
January–March 1965	October 1965
April–December 1965	April 1966

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH. Florida milk network, July–December 1964. Rad Health Data 6:611–612 (November 1965).

(*3*) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine-131 from milk. Public Health Rep:453–456 (May 1965).

(*4*) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, March–July 1965. Rad Health Data 6:540–541 (October 1965).

(*5*) PORTER, C., and B. KAHN. Improved determina- of strontium-90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

(*6*) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January–March 1965. Rad Health Data 6:541–542 (October 1965).

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FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. The most recent coverage of programs reported in *Radiological Health Data and Reports* is listed below:

Program	Period reported	Last presented
Tri-City Diet, HASL	August-October 1965	June 1966
Teenage Diet, FDA	February–November 1964	July 1965
California Diet	May–August 1965	June 1966
Connecticut Standard Diet	January–June 1965	February 1966

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1. Radionuclides in Institutional Diet Samples October–December and Annual Summary 1965

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities distributed as shown in figure 1. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations. Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced to 21 as of July 1965.

Previous results showed that the amount of food consumed by teenage girls is comparable to that consumed by children 9 to 12 years of age, while teenage boys consume 20 percent more (*1, 2*). Consequently, dietary intake for teenage boys and/or girls can be estimated from the levels consumed for children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars,

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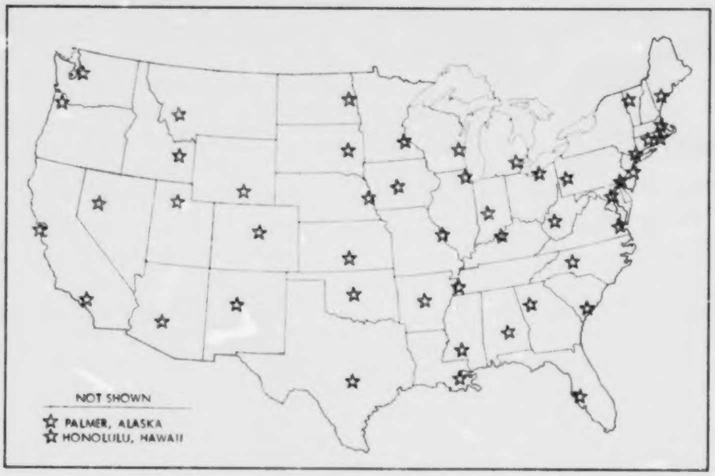

Figure 1. Institutional diet sampling locations

or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures is presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from October through December 1965, for children 9 to 12 years of age. The twenty-one stations reported consist of at least two stations in each of nine geographic areas of the country and one station each in Hawaii and Alaska.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine–131 and barium–140 were interpreted as zero and "less than" 5 pCi/kg of strontium–89 as 2.5 pCi/kg.

The average food consumption rate during this period was 1.80 kg/day and was comparable with the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

While strontium–89 dietary intake remained below detectable levels, the strontium–90 dietary intake during this period remained fairly constant at approximately 23 pCi/day. The strontium–90 intakes fall within Range II as defined by the Federal Radiation Council (*5*), indicating that quantitative surveillance and routine control are recommended.

Cesium–137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*4*). During this period, both barium–140 and iodine–131 concentrations were below detectable levels.

Annual averages

Annual average radionuclide concentrations in 1965 institutional total diet samples are given in table 3. The corresponding annual average intakes are presented in table 4. During 1965 the annual average daily intake varied from 1.28 to 2.73 kg/day, with a mean of 1.89 kg/day. This value is in agreement with the 1961 through 1964 average (*4*). During this same period calcium intakes varied from 0.6

Table 1. Stable element and radionuclide concentrations in institutional diets of children (9–12 years of age), October–December 1965

Location of institution	Month 1965	Stable elements, g/kg of diet		Radionuclide concentrations, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	Oct	0.7	1.4	<5	31	55	0.3
	Nov	0.6	1.6	<5	20	55	0.6
	Dec	0.7	1.2	<5	21	70	0.4
Ariz: Phoenix	Oct	0.3	1.0	<5	13	40	0.3
	Nov	0.4	1.2	<5	8	35	0.1
	Dec	0.5	1.1	<5	14	25	0.3
Ark: Little Rock	Oct	0.6	1.3	<5	20	25	NA
	Nov	0.8	1.3	<5	12	25	NA
	Dec	0.7	1.3	<5	20	25	NA
Calif: Los Angeles	Oct	0.7	1.5	<5	4	35	0.3
	Nov	0.7	1.6	<5	6	15	0.4
	Dec	0.9	1.5	<5	11	35	0.4
Colo: Denver	Oct	0.6	1.3	<5	8	45	0.3
	Nov	0.7	1.5	<5	11	40	0.6
	Dec	0.9	1.5	<5	16	25	0.7
Del: Wilmington	Oct	NS	NS	NS	NS	NS	NS
	Nov	0.8	1.8	<5	10	25	0.9
	Dec	0.8	1.6	<5	11	40	0.1
Fla: Tampa	Oct	0.7	1.8	<5	12	90	NA
	Nov	0.6	1.7	<5	12	90	NA
	Dec	0.6	1.6	<5	11	60	NA
Hawaii: Honolulu	Oct	0.4	1.3	<5	<1	35	0.4
	Nov	0.5	1.5	<5	5	40	0.4
	Dec	0.5	1.3	<5	6	25	0.4
Idaho: Idaho Falls	Oct	1.4	1.6	<5	17	40	0.9
	Nov	1.0	1.6	<5	14	45	0.7
	Dec	1.4	1.6	<5	10	30	0.7
Ill: Chicago	Oct	0.7	1.4	<5	15	50	0.7
	Nov	0.6	1.4	<5	9	40	0.7
	Dec	0.7	1.6	<5	8	45	0.7
Ky: Louisville	Oct	0.6	1.7	<5	14	30	NA
	Nov	0.7	1.7	<5	15	30	NA
	Dec	0.9	1.8	<5	15	25	NA
La: New Orleans	Oct	0.8	1.3	<5	14	35	NA
	Nov	0.8	1.5	<5	19	45	NA
	Dec	0.7	1.6	<5	16	40	NA
Mass: Boston	Oct	0.5	1.5	<5	9	30	0.5
	Nov	0.7	1.1	<5	10	35	0.5
	Dec	0.6	1.4	<5	7	40	1.0
Mo: St. Louis	Oct	0.8	1.5	<5	12	30	0.8
	Nov	0.8	1.8	<5	10	35	0.9
	Dec	0.8	1.6	<5	11	30	0.5
Ohio: Cleveland	Oct	0.6	1.7	<5	6	25	0.5
	Nov	0.6	1.8	<5	6	35	0.7
	Dec	0.8	1.9	<5	12	60	0.9
Pa: Pittsburgh	Oct	0.6	1.3	<5	10	40	0.8
	Nov	0.6	1.4	<5	15	30	0.9
	Dec	0.6	1.2	<5	13	35	0.7
S. C: Charleston	Oct	0.7	1.8	<5	18	40	NA
	Nov	0.7	1.4	<5	16	40	NA
	Dec	0.8	1.7	<5	21	40	NA
S. Dak: Sioux Falls	Oct	0.7	1.3	<5	16	75	0.6
	Nov	0.7	1.4	<5	15	70	0.8
	Dec	0.6	1.7	<5	19	85	0.7
Tex: Austin	Oct	0.6	1.3	<5	6	15	NA
	Nov	0.6	1.4	<5	8	20	NA
	Dec	0.5	1.4	<5	8	25	NA
Vt: Burlington	Oct	0.6	1.4	<5	11	40	0.6
	Nov	0.6	1.6	<5	10	40	0.7
	Dec	1.0	1.8	<5	14	40	1.0
Wash: Seattle	Oct	0.5	1.3	<5	26	55	0.6
	Nov	0.6	1.4	<5	12	50	0.5
	Dec	1.3	1.8	<5	15	45	0.8
Institutional average	Oct	0.6	1.4	<5	13	40	0.5
	Nov	0.7	1.5	<5	12	40	0.6
	Dec	0.8	1.5	<5	13	40	0.6

NA, no analysis NS, no sample

Table 2. Intakes of stable elements and radionuclides in institutional total diet for children (9–12 years of age), October–December 1965

Location of institution		Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	Oct	1.51	1.1	2.1	5	47	85	0.5
		Nov	1.48	0.9	2.4	5	30	80	0.9
		Dec	1.88	1.3	2.3	5	39	130	0.8
Ariz:	Phoenix	Oct	1.77	0.5	1.8	5	23	70	0.5
		Nov	1.37	0.5	1.6	5	11	50	0.1
		Dec	2.00	1.0	2.2	5	28	50	0.6
Ark:	Little Rock	Oct	1.16	0.7	1.5	5	23	30	NA
		Nov	1.78	1.4	2.3	5	21	45	NA
		Dec	1.78	1.2	2.3	5	36	45	NA
Calif:	Los Angeles	Oct	[a] 1.80	1.3	2.7	5	7	65	0.5
		Nov	[a] 2.03	1.4	3.2	5	12	30	0.8
		Dec	[a] 2.40	2.2	3.6	5	26	85	1.0
Colo:	Denver	Oct	2.41	1.4	3.1	5	19	110	0.7
		Nov	2.09	1.5	3.1	5	23	85	1.3
		Dec	2.26	2.0	3.4	5	36	55	1.6
Del:	Wilmington	Oct	NS	NS	NS	NS	NS	NS	NS
		Nov	1.98	1.6	3.6	5	20	50	1.8
		Dec	1.81	1.4	2.9	5	20	70	0.2
Fla:	Tampa	Oct	2.18	1.5	3.9	5	26	195	NA
		Nov	2.01	1.2	3.4	5	24	180	NA
		Dec	1.80	1.1	2.9	5	20	110	NA
Hawaii:	Honolulu	Oct	[a] 1.78	0.7	2.3	5	1	60	0.7
		Nov	1.75	0.9	2.6	5	9	70	0.7
		Dec	1.87	0.9	2.4	5	11	45	0.7
Idaho:	Idaho Falls	Oct	[a] 1.80	2.5	2.9	5	31	70	1.6
		Nov	[a] 1.92	1.9	3.1	5	27	85	1.3
		Dec	[a] 1.99	2.8	3.2	5	20	60	1.4
Ill:	Chicago	Oct	1.14	0.8	1.6	5	17	55	0.8
		Nov	1.53	0.9	2.1	5	14	60	1.1
		Dec	1.26	0.9	2.0	5	10	55	0.9
Ky:	Louisville	Oct	1.28	0.8	2.2	5	18	40	NA
		Nov	1.59	1.1	2.7	5	24	50	NA
		Dec	1.50	1.4	2.7	5	22	40	NA
La:	New Orleans	Oct	1.78	1.4	2.3	5	25	60	NA
		Nov	2.47	2.0	3.7	5	47	110	NA
		Dec	[b] 2.17	1.5	3.5	5	35	85	NA
Mass:	Boston	Oct	2.68	1.3	4.0	5	24	80	1.3
		Nov	2.55	1.8	2.8	5	26	90	1.3
		Dec	2.25	1.4	3.2	5	16	90	2.2
Mo:	St. Louis	Oct	2.28	1.8	3.4	5	27	70	1.8
		Nov	2.39	1.9	4.3	5	24	85	2.2
		Dec	2.38	1.9	3.8	5	26	70	1.2
Ohio:	Cleveland	Oct	1.76	1.1	3.0	5	11	45	0.9
		Nov	1.49	0.9	2.7	5	9	50	1.0
		Dec	1.48	1.2	2.8	5	18	90	1.3
Pa:	Pittsburgh	Oct	[a] 2.32	1.4	3.0	5	23	95	1.9
		Nov	[a] 2.36	1.4	3.3	5	35	70	2.1
		Dec	[a] 2.31	1.4	2.8	5	30	80	1.6
S. C:	Charleston	Oct	1.73	1.2	3.1	5	31	70	NA
		Nov	1.52	1.1	2.1	5	24	60	NA
		Dec	1.86	1.5	3.2	5	39	75	NA
S. Dak:	Sioux Falls	Oct	1.70	1.2	2.2	5	27	130	1.0
		Nov	1.89	1.3	2.6	5	28	130	1.5
		Dec	1.82	1.1	3.1	5	34	155	1.3
Tex:	Austin	Oct	1.70	1.0	2.2	5	10	25	NA
		Nov	1.63	1.0	2.3	5	13	35	NA
		Dec	1.63	0.8	2.3	5	13	40	NA
Vt:	Burlington	Oct	1.77	1.1	2.5	5	19	70	1.1
		Nov	1.43	0.9	2.3	5	14	55	1.0
		Dec	1.23	1.2	2.2	5	17	50	1.2
Wash:	Seattle	Oct	[a] 1.67	0.8	2.2	5	43	90	1.0
		Nov	[a] 1.53	0.9	2.1	5	18	75	0.8
		Dec	[a] 1.63	2.1	2.9	5	24	75	1.3
Institutional average		Oct	1.79	1.1	2.6	5	23	75	1.0
		Nov	1.82	1.2	2.7	5	21	75	1.2
		Dec	1.80	1.3	2.7	5	24	75	1.1

[a] Data for these months were not used in the average because food samples were collected from two or more children over 12 years of age.

[b] Data for these months were not used in the average because food samples were collected from children whose ages were unknown.

NS, no sample collected NA, no analysis

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Table 3. Annual average concentrations of stable elements and radionuclides in institutional daily diets of school children, 1965 [a]

Location of institution		Stable elements, g/kg of diets		Radionuclide concentration, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery [b]	0.6	1.2	<5	12	40	[c] NA
Alaska:	Palmer	0.6	1.3	<5	18	80	0.4
Ariz:	Phoenix [d]	0.6	1.3	<5	14	50	0.5
Ark:	Little Rock	0.7	1.3	<5	21	35	NA
Calif:	Los Angeles	0.7	1.6	<5	8	30	0.6
	San Francisco [e]	0.6	1.6	<5	13	35	0.5
Colo:	Denver	0.7	1.4	<5	14	45	0.6
Conn:	Hartford [b]	0.7	1.6	<5	12	75	0.6
Del:	Wilmington	0.8	1.7	<5	12	50	0.7
Fla:	Tampa	0.7	1.7	<5	12	100	NA
Ga:	Atlanta [b]	0.6	1.6	<5	18	60	NA
Hawaii:	Honolulu	0.5	1.2	<5	11	35	0.6
Idaho:	Idaho Falls	0.9	1.6	<5	21	75	0.6
Ill:	Chicago	0.7	1.5	<5	11	60	0.6
Ind:	Indianapolis [b]	0.8	1.5	5	12	60	0.6
Iowa:	Des Moines [b]	0.6	1.6	<5	14	55	NA
Kans:	Witchita [b]	0.8	1.6	5	15	45	NA
Ky:	Louisville [d]	0.6	1.4	<5	16	35	NA
La:	New Orleans	0.7	1.5	<5	18	50	NA
Maine:	Portland [b]	0.8	1.4	<5	15	90	0.6
Md:	Baltimore [b]	0.6	1.4	<5	15	50	NA
Mass:	Boston (A) [b]	0.7	1.5	<5	14	85	0.6
	Boston (B) [d]	0.6	1.4	<5	9	45	0.6
Mich:	Detroit [b]	0.8	1.6	<5	11	70	0.7
Minn:	Minneapolis [b]	0.7	1.6	<5	30	65	0.7
Miss:	Columbia [b]	0.8	1.5	<5	22	70	NA
Mo:	St. Louis	0.7	1.6	<5	18	40	0.8
Mont:	Helena [b]	0.5	1.2	<5	14	55	0.6
Nebr:	Omaha [b]	0.8	1.5	<5	20	55	0.8
Nev:	Carson City [b]	0.8	1.5	<5	18	40	0.8
N.J:	Trenton [b]	0.7	1.4	<5	12	60	1.0
N. Mex:	Albuquerque [b]	0.8	1.6	<5	12	30	0.7
N.Y:	New York [b]	0.8	1.6	<5	14	75	0.9
N.C:	Charlotte [b]	0.6	1.1	<5	15	40	NA
N. Dak:	Fargo [b]	0.7	1.6	<5	14	70	0.6
Ohio:	Cleveland	0.7	1.7	<5	10	55	0.6
Okla:	Oklahoma City [b]	0.6	1.5	<5	12	35	NA
Ore:	Portland [b]	0.6	1.6	<5	15	50	0.6
Pa:	Pittsburgh	0.6	1.4	<5	13	50	0.7
R.I:	Providence [b] [d]	0.8	1.5	<5	12	75	0.5
S.C:	Charleston	0.7	1.4	<5	18	55	NA
S. Dak:	Sioux Falls	0.8	1.6	<5	16	75	0.7
Tenn:	Memphis [b]	0.6	1.4	<5	16	40	NA
Tex:	Austin	0.5	1.2	<5	8	25	NA
Utah:	Salt Lake City [b]	0.6	1.6	<5	14	65	0.5
Vt:	Burlington	0.8	1.6	<5	14	65	0.6
Va:	Norfolk [b]	0.5	1.2	<5	16	45	NA
Wash:	Seattle	0.7	1.6	<5	21	70	0.5
W. Va:	Charleston [b]	0.8	1.6	<5	19	55	NA
Wis:	Milwaukee [b]	0.6	1.6	<5	10	70	0.7
Wyo:	Laramie [b]	0.7	1.6	<5	15	60	1.0
Institutional average		0.7	1.5	<5	15	55	0.6

[a] Iodine-131 and barium-140 concentrations are not presented in this table; concentrations were reported as not detectable (<10) each month at each institution.

[b] Strontium-90 and cesium-137 concentrations are probably maximum values. Sample collection at these stations was limited to the first half of the year. In general, peak levels for these radionuclides were observed during the first 7 months of 1965.

[c] NA, no analysis

[d] Station entered the network in January 1965.

[e] Values represent data for 3 months.

to 2.0 g/day, with a mean of 1.3 g/day. Potassium annual average intakes ranged from 1.6 to 4.3 g/day, with a mean of 2.8 g/day.

Annual average daily intakes of strontium-89 were less than 10 pCi/day. During 1965, annual average strontium-90 intakes ranged from 13 to 64 pCi/day with a mean of 28 pCi/day. The latter fall within FRC Range II (5), indicating that quantitative surveillance and routine control are the recommended course of action.

Cesium-137 annual average intakes ranged from 40 to 215 pCi/day with a mean of 105 pCi/day. At the same time, radium-226 intakes averaged 1.2 pCi/day.

During 1965, both iodine-131 and barium-140 concentrations were below detectable levels.

Table 4. Annual average intake of selected elements and radionuclides in institutional daily diets of school children, 1965[a]

Location of institution		Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery[b]	2.30	1.3	2.9	5	28	90	[c] NA
Alaska:	Palmer	1.53	1.0	2.0	5	29	125	0.6
Ariz:	Phoenix[d]	1.60	1.0	2.1	5	22	75	0.7
Ark:	Little Rock	1.77	1.2	2.3	5	37	65	NA
Calif:	Los Angeles	1.75	1.3	2.7	5	14	55	1.0
	San Francisco[e]	1.70	1.1	2.7	5	21	60	0.9
Colo:	Denver	2.24	1.5	3.2	5	30	100	1.3
Conn:	Hartford[b]	1.78	1.3	3.0	5	20	135	1.0
Del:	Wilmington	1.89	1.5	3.2	5	23	95	1.3
Fla:	Tampa	2.11	1.5	3.5	5	26	215	NA
Ga:	Atlanta[b]	1.72	1.0	2.8	5	31	110	NA
Hawaii:	Honolulu	1.80	0.9	2.1	5	19	65	1.1
Idaho:	Idaho Falls	1.93	1.7	3.0	10	40	140	1.2
Ill:	Chicago	1.46	1.1	2.2	5	16	85	0.8
Ind:	Indianapolis[b]	1.61	1.3	2.4	10	20	95	0.9
Iowa:	Des Moines[b]	2.73	1.8	4.3	5	39	155	NA
Kans:	Wichita[b]	1.99	1.6	3.2	10	30	90	NA
Ky:	Louisville[d]	1.75	1.2	2.5	5	28	60	NA
La:	New Orleans	2.33	1.6	3.4	5	42	120	NA
Maine:	Portland[b]	2.31	1.8	3.4	5	35	205	1.4
Md:	Baltimore[b]	1.81	1.1	2.4	5	28	90	NA
Mass:	Boston (A)[b]	2.23	1.5	3.3	5	30	190	1.2
	Boston (B)[d]	2.38	1.4	3.3	5	22	100	1.4
Mich:	Detroit[b]	1.88	1.5	2.9	5	20	130	1.4
Minn:	Minneapolis[b]	2.08	1.5	3.4	5	64	140	1.4
Miss:	Columbia[b]	2.30	1.9	3.4	10	49	160	NA
Mo:	St. Louis	2.30	1.7	3.6	5	39	85	1.8
Mont:	Helena[b]	1.35	0.6	1.7	5	20	80	0.8
Nebr:	Omaha[b]	1.79	1.4	2.7	5	36	100	1.4
Nev:	Carson City[b]	1.45	1.2	2.2	5	26	60	1.1
N.J:	Trenton[b]	2.25	1.5	3.2	5	27	135	2.2
N. Mex:	Albuquerque[b]	2.04	1.6	3.2	5	24	65	1.4
N.Y:	New York[b]	2.30	1.7	3.6	5	33	170	2.1
N.C:	Charlotte[b]	1.44	0.9	1.6	5	22	60	NA
N. Dak:	Fargo[b]	1.37	1.0	2.2	5	18	100	0.8
Ohio:	Cleveland	1.56	1.0	2.7	5	16	85	1.0
Okla:	Oklahoma City[b]	1.71	1.1	2.6	5	21	60	NA
Ore:	Portland[b]	2.04	1.1	3.1	5	29	105	1.2
Pa:	Pittsburgh	2.40	1.4	3.4	5	32	125	1.7
R.I:	Providence[b, d]	2.60	2.0	4.0	5	31	200	1.3
S.C:	Charleston	1.72	1.2	2.5	5	32	95	NA
S. Dak:	Sioux Falls	1.78	1.3	2.9	10	29	130	1.2
Tenn:	Memphis[b]	1.58	1.0	2.3	5	26	60	NA
Tex:	Austin	1.74	0.8	2.1	5	13	40	NA
Utah:	Salt Lake City[b]	1.28	0.8	2.0	5	18	85	0.7
Vt:	Burlington	1.41	1.1	2.3	5	19	95	0.9
Va:	Norfolk[b]	2.30	1.2	2.8	5	37	100	NA
Wash:	Seattle	1.74	1.2	2.7	5	37	120	0.9
W. Va:	Charleston[b]	1.69	1.2	2.8	5	32	95	NA
Wis:	Milwaukee[b]	2.08	1.3	3.3	5	22	140	1.6
Wyo:	Laramie[b]	1.58	1.1	2.6	5	24	95	1.5
Institutional average		1.89	1.3	2.8	5	28	105	1.2

[a] Iodine-131 and barium-140 intakes are not presented in this table; values were zero for each month at each institution.

[b] Strontium-90 and cesium-137 intakes are probably maximum values. Sample collection at these stations was limited to the first half of the year. In general, peak levels for these radionuclides were observed during the first 7 months of 1965.

[c] NA, no analysis.

[d] Station entered the network in January 1965.

[e] Values represent data for 3 months.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1964	October 1964
April–June 1964	January 1965
July–September 1964	April 1965
October–December 1964	July 1965
Annual averages 1964	July 1965
January–March 1965	October 1965
April–June 1965	February 1966
July–September 1965	May 1966

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(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Rad Health Data 6: 548–554 (October 1965).

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(*4*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Rad Health Data 6: 691–698 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guidance recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
California Water Sampling Program	January–June 1965	March 1966
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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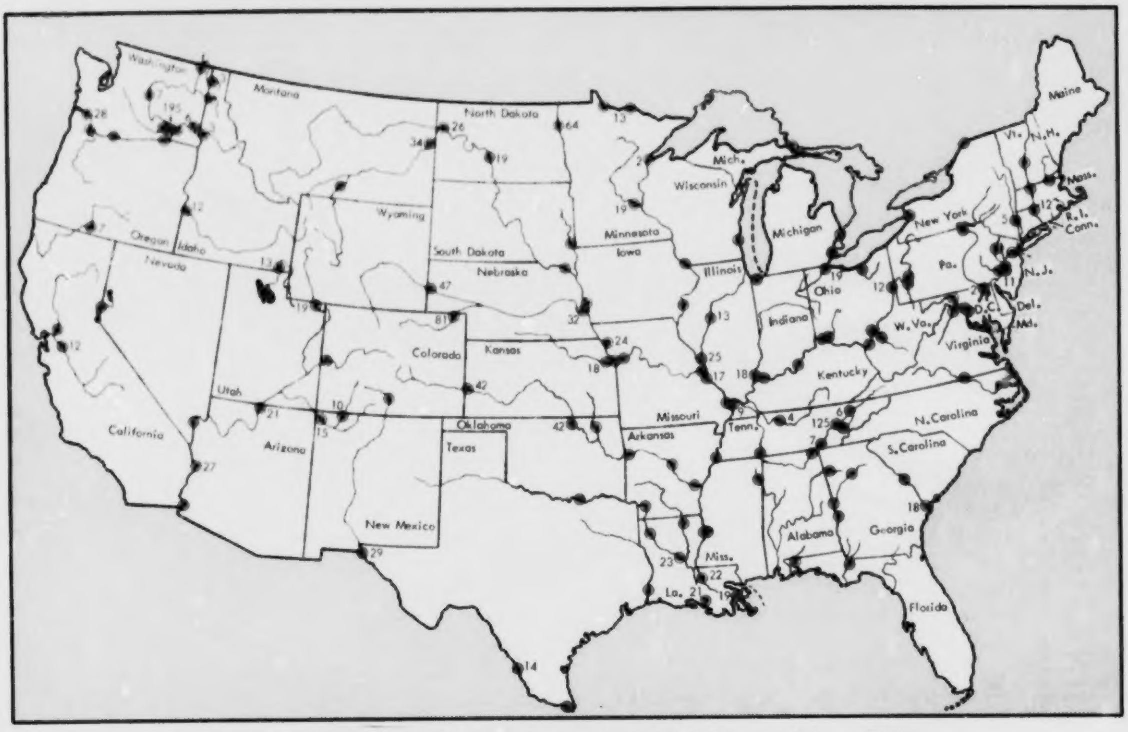
GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JANUARY 1966

Basic Data Program, Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Serv-


Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Ohio
Indiana
W. Va.
Virginia
Nevada
Utah
Colorado
Kansas
Missouri
Kentucky
California
Arizona
New Mexico
Oklahoma
Texas
Arkansas
Tenn.
N. Carolina
S. Carolina
Georgia
Alabama
Miss.
La.
Florida
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125
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5

Figure 1. Sampling locations and associated total beta activity, pCi/liter in surface waters, January 1966

ice drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During December 1965 and January 1966 the following stations showed alpha values in excess of 15 pCi/liter in the dissolved solids:

Arkansas River: Coolidge, Kansas
North Platte River: Henry, Nebraska
South Platte River: Julesburg, Colorado

The station at Pasco, Washington, showed an increase in beta radioactivity in dissolved solids from below 150 pCi/liter in December to more than 150 pCi/liter for January 1966.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) Ibid., 1959 Edition.

(*3*) Ibid., 1960 Edition.

(*4*) Ibid., 1961 Edition.

(*5*) Ibid., 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Table 1. Radioactivity in raw surface waters, January 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	2	8	10	<1	2	2
Arkansas River:						
Coolidge, Kans	5	37	42	1	[illegible]	27
Ponca City, Okla	7	[illegible]	42	1	13	14
Atchafalaya River:						
Morgan City, La	9	[illegible]	21	2	[illegible]	4
Bear River:						
Preston, Idaho	0	13	13	0	[illegible]	2
Chena River:						
Fairbanks, Alaska	<1	2	2	0	0	0
Clearwater River:						
Lewiston, Idaho	1	2	3	0	0	0
Clinch River:						
Clinton, Tenn	1	5	6	0	0	0
Kingston, Tenn *	4	121	125	0	1	1
Colorado River:						
Page, Ariz	0	21	21	0	5	5
Parker Dam, Calif-Ariz	0	27	27	0	13	13
Columbia River:						
Wenatchee, Wash	1	6	7	0	0	0
Pasco, Wash *	28	167	195	0	1	1
Clatskanie, Ore	7	21	28	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn	7	5	12	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	1	3	4	0	0	0
Delaware River:						
Philadelphia, Pa	5	6	11	1	0	1
Great Lakes:						
Duluth, Minn	0	2	2	0	0	0
Green River:						
Dutch John, Utah	0	19	19	0	4	4
Hudson River:						
Poughkeepsie, N.Y	1	4	5	0	0	0
Illinois River:						
Peoria, Ill	3	10	13	0	1	1
Grafton, Ill	6	19	25	2	2	4
Kansas River:						
De Soto, Kans	3	15	18	1	4	5
Klamath River:						
Keno, Ore	1	6	7	0	0	0
Maumee River:						
Toledo, Ohio	5	14	19	1	3	4
Mississippi River:						
St. Paul, Minn	1	18	19	0	1	1
E. St. Louis, Ill	5	12	17	1	1	2
New Roads, La	12	10	22	5	1	6
New Orleans, La	10	9	19	2	1	3
Missouri River:						
Williston, N. Dak	4	22	26	1	5	6
Bismarck, N. Dak	2	17	19	1	3	4
St. Joseph, Mo	5	19	24	1	5	6
North Platte River:						
Henry, Nebr	2	45	47	0	27	27
Ohio River:						
Toronto, Ohio	6	6	12	1	0	1
Cairo, Ill	2	7	9	1	1	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	3	3	0	<1	<1
Platte River:						
Plattsmouth, Nebr	4	28	32	<1	10	10
Rainy River:						
Baudette, Minn	1	12	13	0	0	0
Red River, North:						
Grand Forks, N. Dak	0	64	64	0	3	3
Red River, South:						
Alexandria, La	9	14	23	1	0	1
Rio Grande						
El Paso, Tex	2	27	29	0	4	4
Laredo, Tex	3	11	14	1	4	5
San Joaquin River:						
Vernalis, Calif	5	7	12	2	1	3
San Juan River:						
Shiprock, N. Mex	6	9	15	1	2	3
Savannah River:						
Port Wentworth, Ga *	8	10	18	<1	0	<1
Snake River:						
Payette, Idaho	1	11	12	0	4	4
Wawawai, Wash	0	6	6	0	2	2
South Platte River:						
Julesburg, Colo	15	66	81	5	37	42
Susquehanna River:						
Conowingo, Md	0	2	2	0	0	0
Tennessee River:						
Chattanooga, Tenn	1	6	7	0	0	0
Wabash River:						
New Harmony, Ind	9	9	18	3	<1	3
Yellowstone River:						
Sidney, Mont	1	33	34	0	8	8
Maximum	28	167	195	5	37	42
Minimum	0	2	2	0	0	0

* Gross beta activities at these stations are not directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring redionuclides, common to all stations.

RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES JULY-DECEMBER 1965[1]

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes through the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul; and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

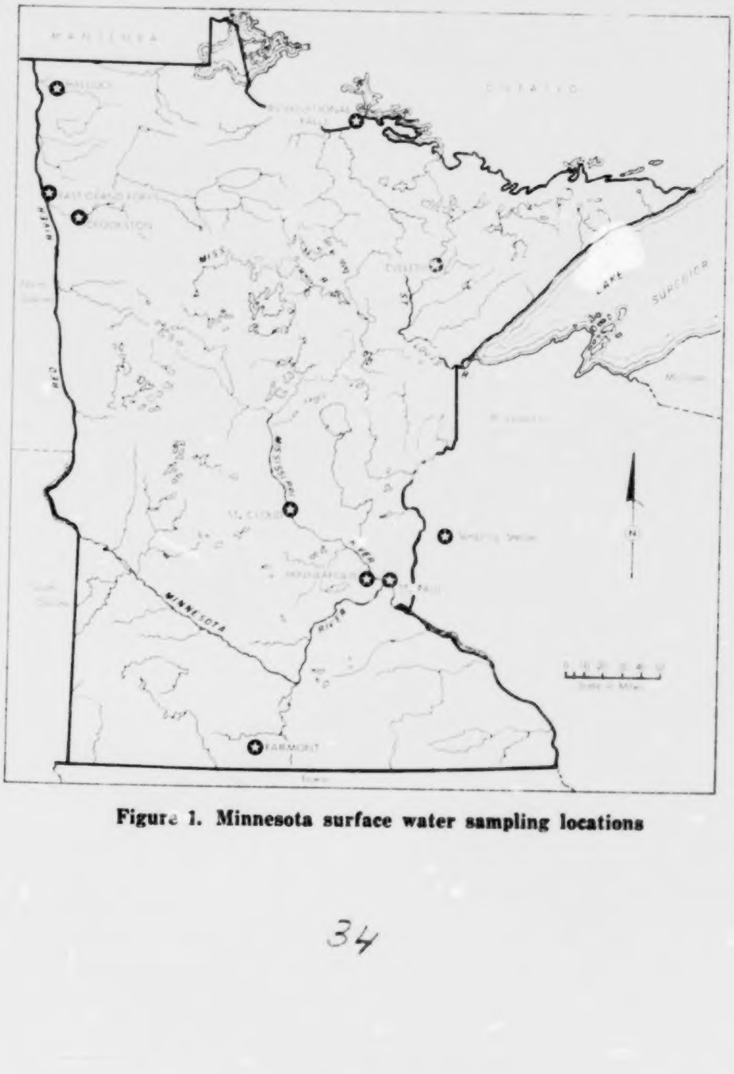
MANITOBA
ONTARIO
HALLOCK
INTERNATIONAL FALLS
EAST GRAND FORKS
CROOKSTON
EVELETH
LAKE SUPERIOR
MISSISSIPPI RIVER
MINNESOTA RIVER
ST. CLOUD
MINNEAPOLIS
ST. PAUL
Sampling Station
FAIRMONT
N

Figure 1. Minnesota surface water sampling locations

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[1] Data and information from "Survey of Environmental Radioactivity, July-December 1965," Pub No. C00-651-25. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minnesota 55440.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta activity in Minnesota municipal water supplies from July through December 1965. The minimum reported level corresponding to an error of one standard deviation is 15 pCi/liter. In averaging, the value 7 pCi/liter is used for samples having less than the minimum detectable value.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 7 to 51 pCi/liter, which is well below the Public Health Service Drinking Water Standard of 1,000 pCi/liter in the known absence of alpha emitters and strontium-90 (*1*). Treated water in most cases contained less beta activity than the corresponding raw water.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 1. Total beta concentrations in Minnesota raw and treated water supplies, July–December 1965

Town and water source	Average concentrations, pCi/liter						
	Type of water	July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	35	NS	38	26	28	13
	Treated	33	NS	7	7	26	36
East Grand Forks, Red Lake River	Raw	27	12	24	24	34	31
	Treated	20	12	9	18	15	10
Eveleth, St. Mary's Lake	Raw	15	18	7	24	21	22
	Treated	17	17	16	23	19	18
Fairmont, Budd Lake	Raw	18	18	15	19	19	11
	Treated	7	9	7	9	7	11
Hallock, Two Rivers, South Fork	Raw	51	40	38	39	32	33
	Treated	15	17	13	14	7	11
International Falls, Rainy River	Raw	7	NS	NS	17	NS	7
	Treated	25	NS	NS	18	NS	12
Minneapolis tap water	Treated	12	11	7	18	9	14
St. Cloud, Mississippi River	Raw	7	NS	7	28	NS	18
	Treated	7	NS	18	14	NS	12
St. Paul, Vadnais Chain of Lakes	Raw	19	14	22	24	21	18
	Treated	11	7	15	19	10	10

NS, no samples collected.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
August 1959–April 1962	August 1962
April 1962–November 1962	April 1963
December 1962–June 1963	November 1963
July–December 1963	June 1964
January–June 1964	January 1965
July–December 1964	August 1965
January–June 1965	February 1966

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity arising through air intrusions such as weapons testing fallout. To date this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last presented
Mexican Air Monitoring Program	December 1965	April 1966
National Air Sampling Network	October–December and annual summary 1965	April 1966
HASL Fallout Network	January–June 1965	May 1966

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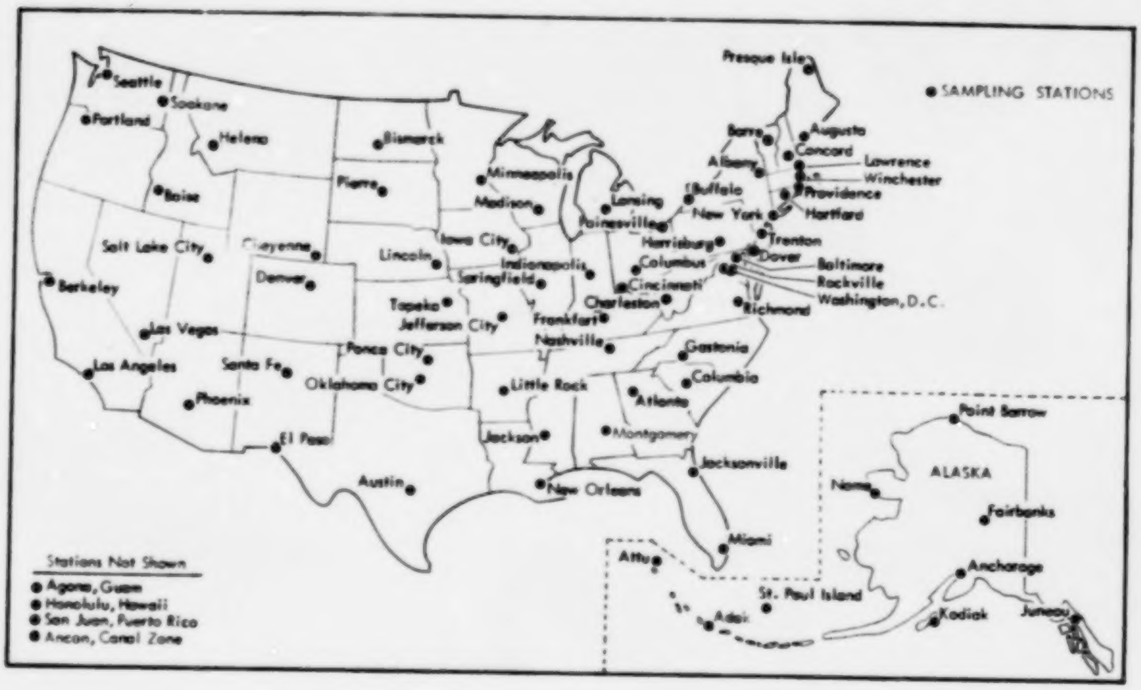
1. Radiation Surveillance Network
March 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during March 1966. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on air samples. Traces of longer-lived fresh fission products were identified in most of these.



● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Denver
Topeka
Jefferson City
Frankfort
Las Vegas
Nashville
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Little Rock
Phoenix
El Paso
Jackson
Austin
New Orleans
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Hartford
Buffalo
New York
Lansing
Painesville
Harrisburg
Trenton
Dover
Columbus
Cincinnati
Baltimore
Rockville
Washington, D.C.
Charleston
Richmond
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
Point Barrow
Nome
ALASKA
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, March 1966

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in RHD&R	Total depth (mm)	Total deposition (nCi/m²) *
		Air	Pptn	Maximum	Minimum	Average *			
Ala:	Montgomery	31	4	0.23	<0.10	<0.13	Feb 66	88	<18
Alaska	Adak	30	NS	0.24	<0.10	<0.11	Jun 66		
	Anchorage	21	1	<0.10	<0.10	<0.10	Mar 66	2	<1
	Attu Island	NS	NS				Jul 66		
	Fairbanks	9	2	<0.10	<0.10	<0.10	Apr 66	3	<1
	Juneau	21	15	<0.10	<0.10	<0.10	May 66	224	<45
	Kodiak	1	NS	0.12	0.12	0.12	May 66		
	Nome	NS	NS				Dec 65		
	Pt. Barrow	31	NS	<0.10	<0.10	<0.10	Nov 65		
	St. Paul Island	31	NS	0.11	<0.10	<0.10	Jan 66		
Ariz:	Phoenix	31	NS	0.39	<0.10	<0.14	May 66		
Ark:	Little Rock	20	1	0.20	<0.10	<0.12	Mar 66	7	<1
Calif:	Berkeley	23	2	0.46	<0.10	<0.16	May 66	14	<3
	Los Angeles	22	1	0.37	<0.10	<0.15	Dec 65	11	<2
C.Z:	Ancon	19	NS	<0.10	<0.10	<0.10	May 66		
Colo:	Denver	30	NS	0.25	<0.10	<0.14	May 66		
Conn:	Hartford	31	10	0.13	<0.10	<0.10	Apr 66	73	<15
Del:	Dover	22	NS	0.15	<0.10	<0.10	Feb 66		
D.C:	Washington	29	7	0.16	<0.10	<0.11	Nov 65	54	<11
Fla:	Jacksonville	31	6	0.17	<0.10	<0.12	Mar 66	88	<18
	Miami	31	5	0.24	<0.10	<0.14	Apr 66	95	<19
Ga:	Atlanta	31	5	0.20	<0.10	<0.12	Jan 66	138	<28
Guam:	Agana	31	NS	<0.10	<0.10	<0.10	Feb 66		
Hawaii:	Honolulu	31	1	0.13	<0.10	<0.10	Jul 66	6	<1
Idaho:	Boise	29	6	0.16	<0.10	<0.11	Jul 66	21	<4
Ill:	Springfield	27	3	0.17	<0.10	<0.11	Nov 65	29	<6
Ind:	Indianapolis	30	7	0.18	<0.10	<0.11	Jan 66	36	<7
Iowa:	Iowa City	31	4	0.15	<0.10	<0.11	May 66	54	<11
Kans:	Topeka	31	NS	0.16	<0.10	<0.11	Mar 66		
Ky:	Frankfort	30	4	0.22	<0.10	<0.13	Nov 65	30	<6
La:	New Orleans	31	6	0.20	<0.10	<0.12	Nov 65	83	<17
Maine:	Augusta	31	12	0.12	<0.10	<0.10	Dec 65	119	<24
	Presque Isle	23	NS	0.13	<0.10	<0.10	May 66		
Md:	Baltimore	22	5	0.19	<0.10	<0.12	Apr 66	28	<6
	Rockville	19	NS	0.15	<0.10	<0.11	Jul 66		
Mass:	Lawrence	31	8	0.24	<0.10	<0.12	Feb 66	52	<10
	Winchester	27	8	0.15	<0.10	<0.10	Jun 66	47	<10
Mich:	Lansing	31	5	0.22	<0.10	<0.12	Jul 66	31	<6
Minn:	Minneapolis	22	3	0.14	<0.10	<0.10	Feb 66	26	<5
Miss:	Jackson	28	2	0.16	<0.10	<0.11	Dec 65	15	<3
Mo:	Jefferson City	31	6	0.18	<0.10	<0.11	Jan 66	36	<7
Mont:	Helena	30	4	0.21	<0.10	<0.13	Jun 66	12	<2
Nebr:	Lincoln	21	[illegible]	0.13	<0.10	<0.10	Jan 66	72	<15
Nev:	Las Vegas	28	NS	0.27	<0.10	<0.15	Apr 66		
N.H:	Concord	22	NS	0.20	<0.10	<0.11	Nov 65		
N.J:	Trenton	31	[illegible]	0.17	<0.10	<0.11	Dec 65	12	<3
N. Mex	Sante Fe	26	5	0.20	<0.10	<0.12	Jun 66	9	<2
N.Y:	Albany	21	[illegible]	0.15	<0.10	<0.10	Jan 66	86	<17
	Buffalo	31	NS	0.13	<0.10	<0.10	May 66		
	New York	31	[illegible]	0.13	<0.10	<0.10	Jun 66		
N.C:	Gastonia	29	4	0.21	<0.10	<0.13	May 66	72	<14
N. Dak	Bismarck	[illegible]	NS	0.13	<0.10	<0.10	Nov 65		
Ohio:	Cincinnati	20	NS	<0.10	<0.10	<0.10	Feb 66		
	Columbus	31	7	0.29	<0.10	<0.16	Dec 65	29	<6
	Painesville	29	11	0.17	<0.10	<0.12	Apr 66	73	<15
Okla:	Oklahoma City	30	4	0.13	<0.10	<0.10	Jul 66	16	<3
	Ponca City	29	NS	<0.10	<0.10	<0.10	Apr 66		
Ore:	Portland	31	8	0.35	<0.10	<0.15	Jan 66	100	<20
Pa:	Harrisburg	20	[illegible]	0.14	<0.10	<0.10	Jan 66	51	<10
P.R:	San Juan	27	[illegible]	0.20	<0.10	<0.11	Dec 65	114	<23
R.I:	Providence	27	[illegible]	0.15	<0.10	<0.10	Jul 66	52	<10
S.C:	Columbia	30	5	0.16	<0.10	<0.12	Jun 66	69	<14
S. Dak:	Pierre	29	[illegible]	0.17	<0.10	<0.11	May 66	10	3
Tenn:	Nashville	30	5	0.19	<0.10	<0.11	Jul 66	29	<6
Tex:	Austin	30	[illegible]	0.22	<0.10	<0.12	Feb 66	16	<3
	El Paso	30	4	0.23	<0.10	<0.13	Nov 65		
Utah:	Salt Lake City	31	7	0.30	<0.10	<0.13	Dec 65	25	<5
Vt:	Barre	30	9	0.18	<0.10	<0.11	Mar 66	55	<11
Va:	Richmond	[illegible]	6	0.29	<0.10	<0.11	Mar 66	50	<10
Wash:	Seattle	31	17	0.13	<0.10	<0.10	Mar 66	81	<16
	Spokane	[illegible]	5	0.22	<0.10	<0.12	Feb 66	35	<7
W. Va:	Charleston	[illegible]	6	0.17	<0.10	<0.11	Jun 66	40	<8
Wis:	Madison	[illegible]	7	0.15	<0.10	<0.10	Mar 66	56	<11
Wyo:	Cheyenne	[illegible]	NS	0.24	<0.10	<0.14	Apr 66		
Network summary		[illegible]	283	0.46	<0.10	<0.11		50	<10

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

NS, no air or precipitation sample collected.

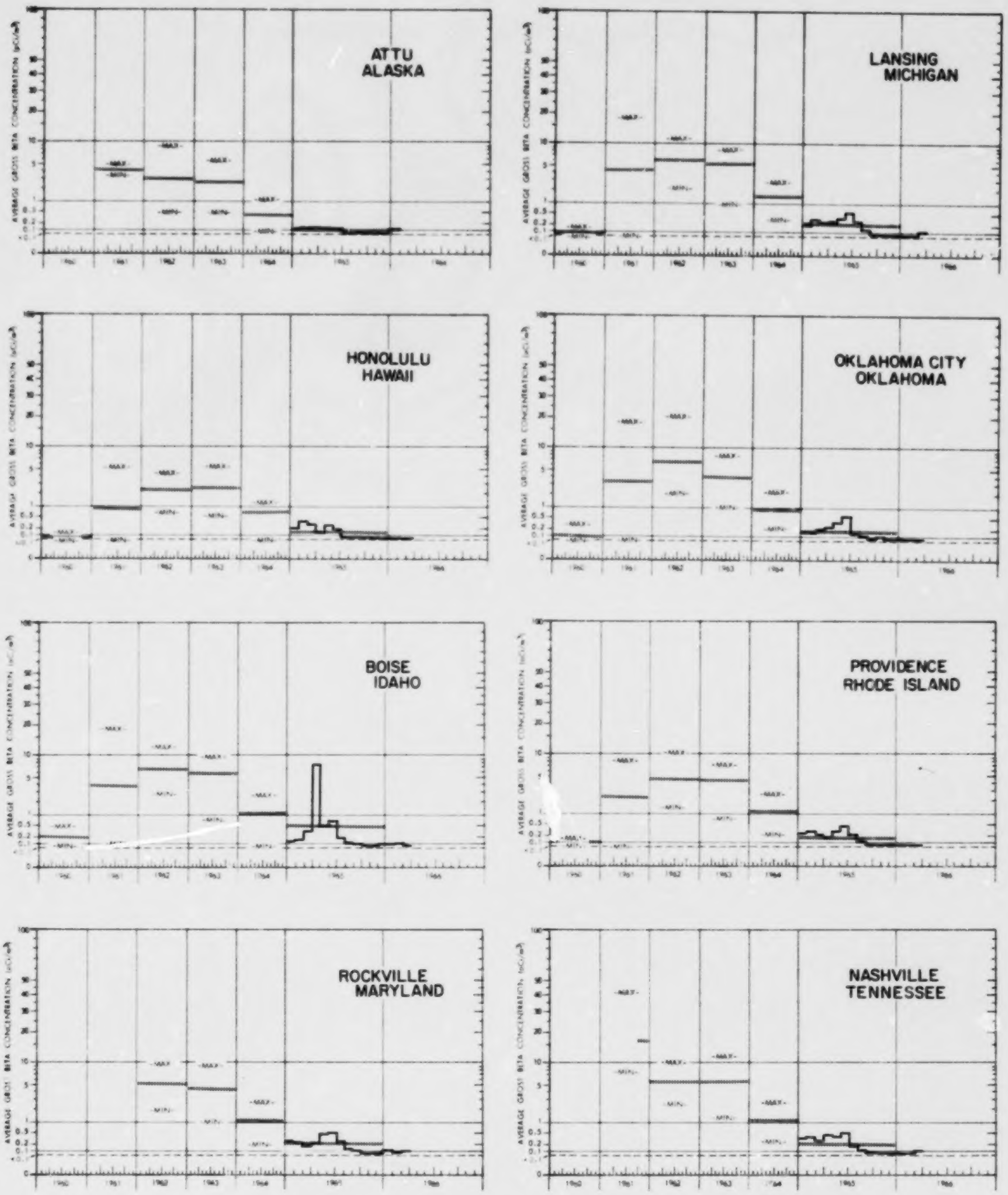


Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960—March 1966

2. Canadian Air and Precipitation Monitoring Program, March 1966[1]

Radiation Protection Division
Department of National Health and
Welfare, Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for March 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, March 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	180	0.8
Coral Harbour	31	0.2	0.0	0.1	69	0.9
Edmonton	31	0.2	0.0	0.1	73	0.7
Ft. Churchill	31	0.2	0.1	0.1	23	0.6
Ft. William	31	0.2	0.0	0.1	65	3.7
Fredericton	31	0.2	0.0	0.1	28	1.9
Goose Bay	31	0.2	0.0	0.1	17	0.5
Halifax	31	0.2	0.0	0.1	30	3.5
Inuvik	31	0.2	0.1	0.1	NS	NS
Montreal	31	0.2	0.0	0.1	20	1.5
Moosonee	31	0.2	0.0	0.1	16	1.4
Ottawa	31	0.2	0.0	0.1	21	1.5
Quebec	31	0.1	0.0	0.1	23	2.9
Regina	31	0.2	0.0	0.1	139	1.0
Resolute	31	0.2	0.0	0.1	NS	NS
St. John's, Nfld	31	0.2	0.0	0.1	16	1.8
Saskatoon	30	0.2	0.0	0.1	53	0.7
Sault Ste. Marie	30	0.2	0.0	0.1	38	3.2
Toronto	31	0.2	0.0	0.1	68	3.9
Vancouver	31	0.2	0.0	0.1	28	2.6
Whitehorse	31	0.2	0.0	0.1	57	0.7
Windsor	31	0.2	0.1	0.1	53	3.3
Winnipeg	31	0.2	0.0	0.1	23	0.9
Yellowknife	31	0.2	0.1	0.1	27	0.5
Network summary		0.2	0.0	0.1	49	1.8

NS, no sample collected

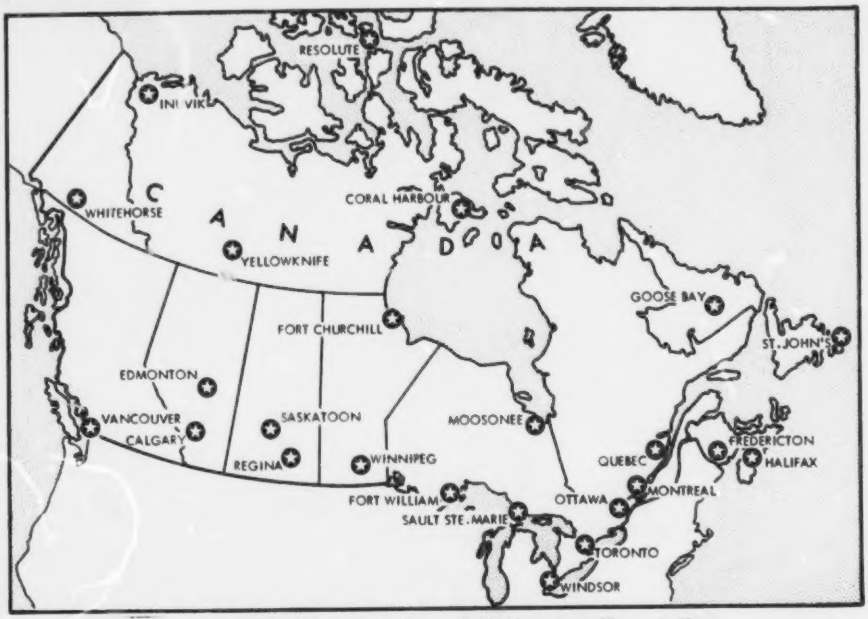

RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
MONTREAL
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the April 1966 monthly report "Data from Radiation Protection Programs." Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Air Sampling Program March 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas, under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 4.

The March 1966 air-monitoring results from the participating countries are given in table 3.

Table 3. PAHO gross beta activity in surface air and precipitation, March 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	13	<0.10	<0.10	<0.10
Chile: Santiago	28	<0.10	<0.10	<0.10
Jamaica: Kingston	24	0.12	<0.10	<0.10
Peru: Lima	25	<0.10	<0.10	<0.10
Venezuela: Caracas	21	0.13	<0.10	<0.10
West Indies: Trinidad	21	0.11	<0.10	<0.10
Pan American summary	132	0.13	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

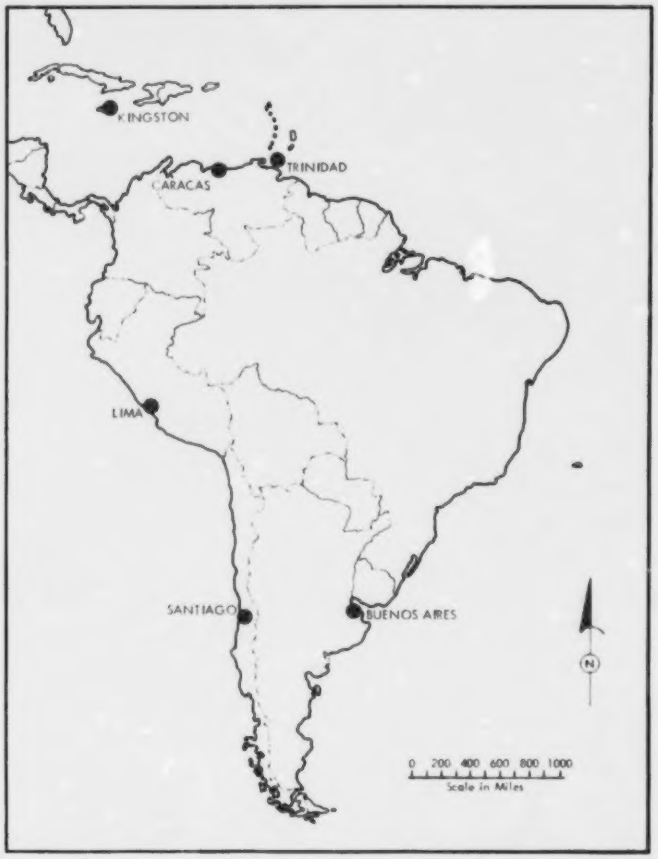

Figure 4. Pan American Air Network sampling stations

4. National Air Sampling Network January–March 1966

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed by the NASN on their air samples is for gross beta radioactivity. NASN stations (figure 5) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operate every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data*. First quarter 1966 gross beta activities in air are given in table 4.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
October–December and annual summary 1964	April 1965
January–March 1965	July 1965
April–June 1965	October 1965
July–September 1965	January 1966
October–December and annual summary 1965	April 1966

REFERENCES

(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025. Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Rad Health Data 5:12–15 (January 1964).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH, RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Washington, D.C. 20201 (distribution by official request).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

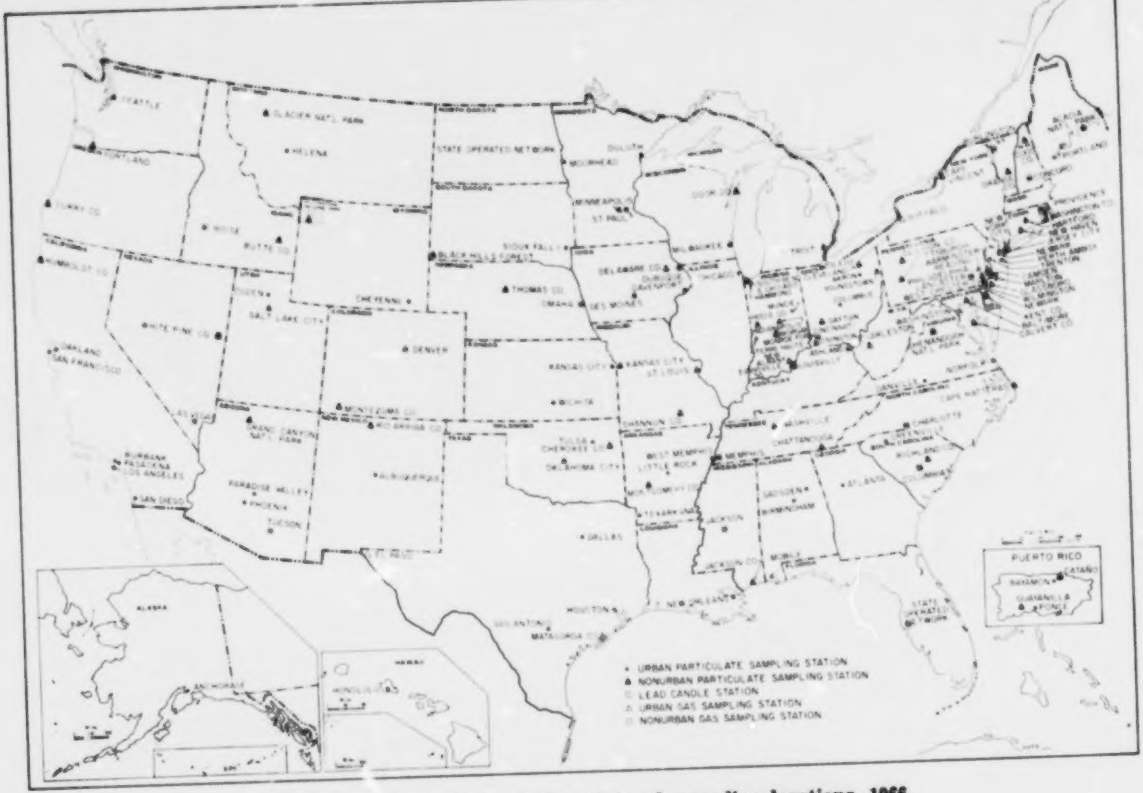
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
□ LEAD CANDLE STATION
△ URBAN GAS SAMPLING STATION
□ NONURBAN GAS SAMPLING STATION
ALASKA
ANCHORAGE
HAWAII
HONOLULU
PUERTO RICO
SAN JUAN
CATAÑO
SEATTLE
PORTLAND
GLACIER NAT'L PARK
HELENA
BOISE
BUTTE CO
CHEYENNE
SALT LAKE CITY
DENVER
OAKLAND
SAN FRANCISCO
LOS ANGELES
SAN DIEGO
PHOENIX
TUCSON
ALBUQUERQUE
DALLAS
HOUSTON
SAN ANTONIO
KANSAS CITY
ST LOUIS
WICHITA
OMAHA
DES MOINES
MINNEAPOLIS
ST PAUL
DULUTH
CHICAGO
MILWAUKEE
DETROIT
LITTLE ROCK
MEMPHIS
NEW ORLEANS
JACKSON
BIRMINGHAM
ATLANTA
CHATTANOOGA
NASHVILLE
CHARLOTTE
NORFOLK
CAPE HATTERAS
BUFFALO
STATE OPERATED NETWORK

Figure 5. National Air Sampling Network sampling locations, 1966

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Table 4. NASN fission product gross beta activity in surface air, January–March 1966

Station name		Number of samples	Concentration, pCi/m³		
			Maximum	Minimum	Average
Ala:	Birmingham	6	0.3	0.1	0.2
	Gadsden	6	0.3	<0.1	0.1
	Mobile	6	0.2	0.1	0.2
Alaska:	Anchorage	5	0.2	<0.1	0.1
Ariz:	Grand Canyon Park [a]	6	0.2	<0.1	0.1
	Paradise Valley	6	0.2	0.1	0.2
	Phoenix	6	0.3	0.1	0.2
	Tucson	6	0.2	0.1	0.2
Ark:	Little Rock	6	0.2	0.1	0.1
	Montgomery County [a]	6	0.2	0.1	0.1
	Texarkana	5	0.2	0.1	0.2
	West Memphis	7	0.2	0.1	0.2
Calif:	Burbank	6	0.3	0.1	0.2
	Humboldt County [a]	6	0.1	<0.1	0.1
	Los Angeles	6	0.3	0.1	0.2
	Oakland	6	0.4	0.1	0.2
	Pasadena	6	0.2	0.1	0.1
	San Diego	5	0.1	<0.1	0.1
	San Francisco	6	0.1	<0.1	0.1
Colo:	Denver	6	0.3	0.1	0.2
	Montezuma County [a]	6	0.4	0.1	0.2
Conn:	Hartford	6	0.2	<0.1	0.1
	New Haven	6	0.2	<0.1	0.1
Del:	Kent County [a]	6	0.2	0.1	0.1
	Newark	6	0.2	0.1	0.1
	Wilmington	6	0.2	0.1	0.1
D.C:	Washington	6	0.1	0.1	0.1
Ga:	Atlanta	5	0.3	0.1	0.2
Hawaii:	Honolulu	6	0.1	0.1	0.1
Idaho:	Boise	6	0.2	0.1	0.2
	Butte County [a]	6	0.2	0.1	0.1
Ill:	Chicago	6	0.2	0.1	0.1
Ind:	East Chicago	6	0.2	0.1	0.1
	Hammond	6	0.1	0.1	0.1
	Indianapolis	6	0.2	0.1	0.2
	N. Monroe St. Forest [a]	5	0.2	0.1	0.1
	Muncie	5	0.3	0.1	0.2
	New Albany	6	0.3	0.1	0.2
	Parke County [a]	6	0.2	0.1	0.1
	South Bend	5	0.2	0.1	0.1
	Terre Haute	5	0.3	0.1	0.2
Iowa:	Davenport	6	0.2	0.1	0.2
	Delaware County [a]	6	0.2	0.1	0.1
	Des Moines	6	0.2	0.1	0.2
	Dubuque	6	0.2	0.1	0.1
Kans:	Kansas City	6	0.2	0.1	0.1
	Wichita	6	0.2	0.1	0.2
Ky:	Ashland	5	0.2	0.1	0.1
	Covington	6	0.2	0.1	0.2
	Louisville	5	0.1	0.1	0.1
La:	New Orleans	6	0.3	0.1	0.2
Maine:	Acadia Nat'l Park [a]	6	0.2	<0.1	0.1
	Portland	4	0.1	<0.1	0.1
Md:	Baltimore	6	0.1	0.1	0.1
	Calvert County [a]	6	0.1	<0.1	0.1
Mich:	Detroit	6	0.2	<0.1	0.1
Minn:	Duluth	6	0.2	0.1	0.2
	Minneapolis	6	0.2	0.1	0.1
	Moorhead	6	0.2	0.1	0.1
	St. Paul	6	0.2	0.1	0.1
Miss:	Jackson	6	0.3	<0.1	0.2
	Jackson County [a]	6	0.2	<0.1	0.1
Mo:	Kansas City	5	0.2	0.1	0.1
	St. Louis	5	0.2	0.1	0.1
	Shannon County [a]	6	0.2	0.1	0.2
Mont:	Glacier Nat'l Park [a]	6	0.2	<0.1	0.1
	Helena	6	0.2	0.1	0.1
Nebr:	Omaha	5	0.2	0.1	0.1
	Thomas County [a]	6	0.3	0.1	0.2
Nev:	Las Vegas	6	0.2	0.1	0.2
	White Pine County [a]	5	0.1	0.1	0.1
N.H:	Concord	6	0.2	<0.1	0.1
	Coos County [a]	6	0.2	<0.1	0.1
N.J:	Marlton	6	0.1	0.1	0.1
	Camden	5	0.2	0.1	0.1
	Glassboro	6	0.1	0.1	0.1
	Jersey City	5	0.2	0.1	0.1
	Newark	6	0.2	<0.1	0.1
	Perth Amboy	5	0.1	0.1	0.1
	Trenton	6	0.2	<0.1	0.1
N. Mex:	Albuquerque	6	0.3	0.1	0.2
	Rio Arriba Co.[a]	6	0.3	0.1	0.2
N.Y:	Cape Vincent [a]	5	0.1	0.1	0.1
	New York City	5	0.1	<0.1	0.1
N.C:	Charlotte	6	0.3	<0.1	0.1
	Cape Hatteras [a]	6	0.1	<0.1	0.0
Ohio:	Akron	6	0.3	<0.1	0.2
	Cincinnati	5	0.3	0.2	0.2
	Cleveland	6	0.2	<0.1	0.1
	Columbus	6	0.3	0.1	0.2
	Dayton	6	0.2	0.1	0.1
	Toledo	6	0.2	<0.1	0.1
	Youngstown	6	0.2	0.1	0.1
Okla:	Cherokee County [a]	6	0.2	0.1	0.2
	Oklahoma City	6	0.2	0.1	0.2
	Tulsa	6	0.4	0.2	0.2
Ore:	Curry County [a]	6	0.2	0.1	0.1
	Portland	6	0.1	<0.1	0.1
Pa:	Clarion County [a]	5	0.2	0.1	0.1
	Lancaster	6	0.2	0.1	0.1
	Philadelphia	6	0.1	0.1	0.1
	Pittsburgh	6	0.2	0.1	0.1
	Reading	5	0.4	0.1	0.2
	Warminster	5	0.1	<0.1	0.1
	West Chester	5	0.2	0.1	0.1
P.R:	Bayamon	6	0.2	<0.1	0.1
	Guayanilla	6	0.2	<0.1	0.1
	Ponce	6	0.2	<0.1	0.1
	San Juan	6	0.2	<0.1	0.1
R.I:	Providence	6	0.3	0.1	0.1
	Washington County [a]	6	0.2	<0.1	0.1
S.C:	Columbia	6	0.2	0.1	0.2
	Greenville	6	0.2	0.1	0.2
	Richland County [a]	6	0.2	0.1	0.2
S. Dak:	Black Hills Forest [a]	6	0.2	0.1	0.1
	Sioux Falls	6	0.2	0.0	0.1
Tenn:	Chattanooga	5	0.2	0.1	0.2
	Memphis	6	0.2	0.1	0.1
	Nashville	6	0.2	0.0	0.1
Tex:	Dallas	6	0.2	0.1	0.1
	Houston	6	0.2	<0.1	0.1
	Matagorda County [a]	5	0.2	0.1	0.1
	San Antonio	5	0.2	0.1	0.1
Utah:	Ogden	6	0.2	0.1	0.1
	Salt Lake City	5	0.2	0.1	0.1
Vt:	Burlington	6	0.2	<0.1	0.1
	Orange County [a]	6	0.1	<0.1	0.1
Va:	Danville	6	0.2	0.1	0.1
	Norfolk	6	0.1	<0.1	0.1
	Shenandoah Nat'l Park [a]	6	0.3	0.1	0.2
Wash:	Seattle	6	0.2	0.1	0.1
W. Va:	Charleston	5	0.2	0.1	0.2
Wis:	Door County [a]	6	0.2	0.1	0.1
	Milwaukee	5	0.1	0.1	0.1
Wyo:	Cheyenne	6	0.2	<0.1	0.1
	Yellowstone Nat'l Park [a]	5	0.2	0.1	0.1

[a] Denotes nonurban station.

(*4*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*6*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of the environmental radioactivity data follow for the Paducah Plant, the Portsmouth Area Gaseous Diffusion Plant, and the Shippingport Atomic Power Station.

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[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection Against Radiation, AEC Rules and Regulations," contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Paducah Plant

July–December and Calendar Year 1965[3]

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. A former source of diffusion plant feed, the uranium hexafluoride manufacturing plant was placed on standby in June of 1964. Parts of the associated uranium metal foundry are operated infrequently as the need arises; otherwise, it is also on standby status. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, or ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234, and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

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[3] Summarized from "Environmental Concentrations of Radioactive Materials Near the Paducah Plant Report for the Year and for the Second Half of 1965."

Because uranium is a rather expensive element, as much of it is recovered as is feasible. The added desire to maintain a wholesome relationship with neighboring communities and individuals makes it essential that entrained dust be filtered from exhaust systems, and that all effluent waters be maintained at extremely low concentrations of uranium.

An environmental monitoring system checks the effectiveness of the confinement and recovery systems of the plant. The environmental monitoring program provides for continuous sampling of the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 1). Air is filtered at 0.3 cubic feet per minute through 2-inch-diameter membrane filters which are replaced weekly and counted for alpha and beta activity. Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air-sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those listed in the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area which have resulted from operations within the controlled area shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion of data

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 4.

The average alpha counts—interpreted as uranium, the most likely source of activity—of the 234 air samples collected during the second half of 1965, and of the 468 air samples collected during calendar year 1965, were both 1 percent of the concentration limit for people residing in the vicinity of a controlled area. The mean beta counts of the same samples were

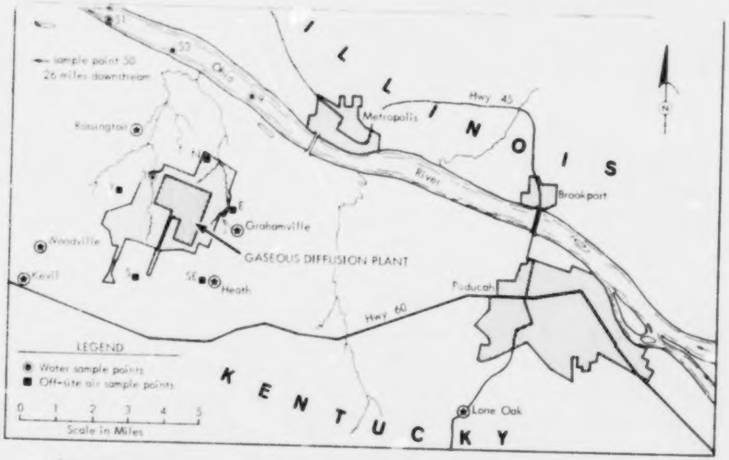

Figure 1. Sampling locations, Paducah Gaseous Diffusion Plant

Table 1. Uranium concentrations in outdoor air samples Paducah Plant, 1965

Sample location [a]	Number of samples	Uranium alpha [b] (pCi/m³) Maximum	Uranium alpha [b] (pCi/m³) Minimum [c]	Uranium alpha [b] (pCi/m³) Mean	Mean as percent of concentration limit [d]
January-June, 1965					
At plant perimeter fence					
North	26	0.13	<0.02	0.03	1
East	26	0.16	<0.02	0.02	1
South	26	0.11	<0.02	0.02	1
West	26	0.08	<0.02	0.02	1
Totals	104	0.16	<0.02	0.02	1
About 1 mile outside plant perimeter fence					
North	26	0.05	<0.02	0.02	1
East	26	0.07	<0.02	0.02	1
South	26	0.07	<0.02	0.02	1
West	26	0.10	<0.02	0.02	1
Southeast	26	0.09	<0.02	0.02	1
Totals	130	0.10	<0.02	0.02	1
July-December, 1965					
At plant perimeter fence					
North	26	0.13	<0.02	0.02	1
East	26	0.38	<0.02	0.03	1
South	26	0.10	<0.02	0.02	1
West	26	0.13	<0.02	0.02	1
Totals	104	0.38	<0.02	0.02	1
About 1 mile outside plant perimeter fence					
North	26	0.09	<0.02	0.02	1
East	26	0.11	<0.02	0.02	1
South	26	0.12	<0.02	0.02	1
West	26	0.08	<0.02	0.02	1
Southeast	26	0.08	<0.03	0.02	1
Totals	130	0.12	<0.02	0.02	1
Calendar year, 1965					
At plant perimeter fence					
North	52	0.13	<0.02	0.03	1
East	52	0.38	<0.02	0.02	1
South	52	0.11	<0.02	0.02	1
West	52	0.13	<0.02	0.02	1
Totals	208	0.38	<0.02	0.02	1
About 1 mile outside plant perimeter fence					
North	52	0.09	<0.02	0.02	1
East	52	0.11	<0.02	0.02	1
South	52	0.12	<0.02	0.02	1
West	52	0.10	<0.02	0.02	1
Soutleast	52	0.09	<0.02	0.02	1
Totals	260	0.12	<0.02	0.02	1

[a] See figure 1.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 x 10^4 alpha dis/sec.

[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³

[d] The concentration limit for natural uranium in air released to the environs is 2 pCi/m³.

0.02 percent and 0.03 percent of the concentration limit, respectively. Due to a clerical error at the Paducah Plant, certain values for the first half of 1965 were incorrectly reported in the January issue of *Radiological Health and Reports*. The correct values are reported in tables 1 and 2.

The averages of uranium analyses of weekly water samples collected by a continuous water sampler in Big Bayou Creek for the second half of 1965 and the calendar year 1965, were both 0.05 percent of the concentration limit for water beyond a controlled area. The results of the uranium analyses for each of the 12 grab samples collected each month from the Ohio River below the plant were less than 0.01 percent of the concentration limit.

The concentration of beta emitters in Big Bayou Creek averaged less than 0.5 percent of the concentration limit for the decay products of uranium–238 during the second half of 1965; the average for the year was 0.5 percent of the concentration limit. The beta activity of the Ohio River was at or below the minimum detectable level during the second half of 1965, and the results of all samples during the year averaged 0.5 percent of the concentration limit for uranium–238 decay products.

Table 2. Beta concentrations in outdoor air samples Paducah Plant, 1965

Sample location [a]	Number of samples	Beta, pCi/m³ Maximum	Beta, pCi/m³ Minimum [b]	Beta, pCi/m³ Mean	Mean as percent of concentration limit [c]
January-June 1965					
At plant perimeter fence					
North	26	1.6	0.2	0.6	0.06
East	26	1.0	0.1	0.4	0.04
South	26	0.8	0.1	0.4	0.04
West	26	1.0	<0.1	0.4	0.04
Totals	104	1.6	<0.1	0.4	0.05
About 1 mile outside plant perimeter fence					
North	26	1.1	0.15	0.4	0.04
East	26	0.9	0.11	0.4	0.04
South	26	1.0	0.16	0.4	0.04
West	26	1.0	0.13	0.4	0.04
Southeast	26	0.9	0.20	0.4	0.04
Totals	130	1.1	0.11	0.4	0.04
July-December 1965					
At plant perimeter fence					
North	26	0.4	<0.1	0.2	0.02
East	26	1.2	<0.1	0.2	0.02
South	26	0.4	<0.1	0.1	0.01
West	26	0.5	<0.1	0.1	0.01
Totals	104	1.2	<0.1	0.1	0.02
About 1 mile outside plant perimeter fence					
North	26	0.6	<0.1	0.2	0.02
East	26	0.5	<0.1	0.2	0.02
South	26	0.4	<0.1	0.2	0.02
West	26	0.6	<0.1	0.2	0.02
Southeast	26	0.6	<0.1	0.2	0.02
Totals	130	0.6	<0.1	0.2	0.02
Calendar year 1965					
At plant perimeter fence					
North	52	1.6	<0.1	0.4	0.04
East	52	1.2	<0.1	0.3	0.03
South	52	0.8	<0.1	0.3	0.03
West	52	1.0	<0.1	0.3	0.03
Totals	208	1.6	<0.1	0.3	0.03
About 1 mile outside plant perimeter fence					
North	52	1.1	<0.1	0.3	0.03
East	52	0.9	<0.1	0.3	0.03
South	52	1.0	<0.1	0.3	0.03
West	52	1.0	<0.1	0.3	0.03
Southeast	52	0.9	<0.1	0.3	0.03
Totals	260	1.1	<0.1	0.3	0.03

[a] See figure 1.

[b] The minimum detectable amount of beta emitters in air is 0.1 pCi/m³.

[c] The concentration limit applicable to this table is 1,000 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Table 3. Concentration of uranium in water, Paducah Plant, July–December 1965 and calendar year 1965

Sample location [a]	Number of samples	Uranium, pCi/liter [b]			Mean as per-cent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
July–December 1965					
Big Bayou Creek 3	26	33	<1	10	0.05
Ohio River 9	6	1	<1	<1	<0.01
Composite of 50, 51, 52, and 53	6	2	<1	<1	<0.01
Calendar year 1965					
Big Bayou Creek 3	52	33	<1	9	0.05
Ohio River 9	12	1	<1	<1	<0.01
Composite of 50, 51, 52, and 53	12	2	<1	<1	<0.01

[a] See figure 1.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 x 10^4 dis/sec.
[c] The minimum detectable uranium in water is 1 pCi/liter.
[d] The concentration limit for natural uranium in water beyond a controlled area is 20,000 pCi/liter.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hour at all sampling stations in 1965.

Table 4. Concentration of beta emitters in water, Paducah Plant, July–December and calendar year 1965

Sample location [a]	Number of samples	Beta emitters (pCi/liter)			Mean as per-cent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
July–December 1965					
Big Bayou Creek 3	26	100	<100	<100	<0.5
Ohio River 9	6	100	<100	<100	<0.5
Composite of 50, 51, 52, and 53	6	700	<100	200	1
Calendar year 1965					
Big Bayou Creek 3	52	2,200	<100	100	0.5
Ohio River 9	12	700	<100	100	0.5
Composite of 50, 51, 52, and 53	12	700	<100	100	0.5

[a] See figure 1.
[b] The minimum detectable amount of beta emitters in water is 100 pCi/liter.
[c] The concentration limit for the daughter products of uranium in water released to the environs in 20,000 pCi/liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	January 1962
July–December 1961	August 1962
1962	September 1963
1963	July 1964
January–June 1964	February 1965
1964	July 1965
January–June 1965	January 1966

2. Portsmouth Area Gaseous Diffusion Plant July–December 1965 [4]

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the radionuclides most likely to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium–234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

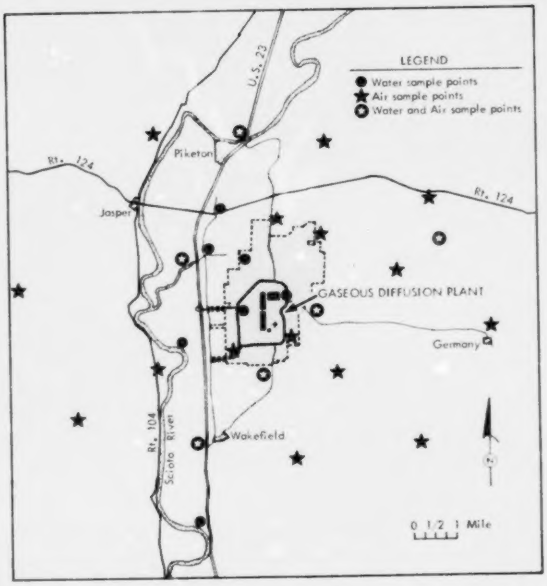

Figure 2. Air sampling locations, Portsmouth Area Gaseous Diffusion Plant

Continuous air samples are collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 2. Monthly water samples are collected at 13 stations within 5 miles of the plant.

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[4] Data summarized from B. Kalmon: "Environmental Radiation Levels and Concentrations, Second Half and Annual Summary 1965," GAT 506 (February 18, 1966).

For the second half of 1965, both the airborne alpha and the beta-gamma activity dropped significantly compared to the first half of 1965. The alpha airborne average for the second half of the calendar year dropped from 16.1 percent to 9.7 percent of the concentration limit. The beta-gamma concentration was less than 0.01 percent, compared to 0.05 percent for the first half.

During the last half of 1965, the average alpha concentration in the water effluents increased, while the beta-gamma activity decreased. In July and August, higher than usual concentrations of radioactivity were detected in water at sample point 11. The highest individual results for alpha and beta-gamma were 12 and 18 percent, respectively, of the concentration limit. Point 11 receives the direct discharge of an effluent holding pond prior to additional dilution and prior to leaving the plant boundaries.

Annual background exposure rates continued to decline in 1965, decreasing from 48 percent to 22.8 percent of the permissible exposure limits in the past year. The second half of 1965 was also lower than the first half of 1965. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity, with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma concentrations in air and water are summarized in table 5. The external gamma levels, measured at the air-sampling locations shown in figure 2, are also summarized in table 5. The overall average concentrations and background exposure rates for July to December 1965 are presented in table 6, along with the values for the first half of 1965 and the calendar years 1964 and 1965.

Table 5. Environmental radioactivity, Portsmouth Plant July–December 1965

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as percent of concentration limit [a]
Air					
Alpha concentration pCi/m^3	89	0.9	<0.1	0.2	9.7
Beta-gamma concentration pCi/m^3	89	0.9	<0.1	<0.1	<0.01
Water					
Alpha concentration pCi/liter	61	2,610	<0.5	90.4	0.45
Beta-gamma concentration pCi/liter	62	1,035	<14.0	35.4	0.18
External beta-gamma [b] mrad/hr	91	0.04	0.01	0.02	24

[a] The applicable concentration or exposure limits are as follows:

Air (alpha)	2 pCi/m^3
(beta-gamma)	1,000 pCi/m^3
Water (alpha)	20,000 pCi/liter
(beta-gamma)	20,000 pCi/liter
External beta-gamma	500 mrad/yr (approximately 0.06 mrad/hr)

[b] Measurements were made with open shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration limit.

Table 6. Comparison of average concentrations Portsmouth Plant

Type of monitoring	Percent of concentration or exposure limit [a]			
	1964	1965		
	Calendar year	First half	Second half	Calendar year
Air				
Alpha concentration	5.0	16.1	9.7	13.8
Beta-gamma concentration	0.15	0.05	<0.01	0.03
Water				
Alpha concentration	0.07	0.19	0.45	0.30
Beta-gamma concentration	<0.07	0.49	0.18	0.32
Overall background exposure extrapolated to 3 feet above ground	48	30	24	28

[a] See footnote (a) of table 5.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
First and second quarters 1961	February 1962
Third and fourth quarters 1961	September 1962
1962	May 1963
1963	July 1964
January–June 1964	February 1965
1964	July 1965
January–June 1965	January 1966

3. Shippingport Atomic Power Station July–December 1965[5]

Duquesne Light Company
Shippingport, Pennsylvania

The Shippingport Atomic Power Station is operated for the Atomic Energy Commission by the Duquesne Light Company. The plant site is located near Shippingport, Pennsylvania, along the Ohio River about 25 miles northwest of Pittsburgh.

The pressurized water reactor with core 1 ("seed and blanket" design) achieved full power on December 23, 1957, and has operated continuously except for shutdowns which were necessary for maintenance and "seed" refueling. In February 1964, the reactor was shut down for the replacement of core 1 with core 2, the decontamination of the primary system, and the commencement of other associated reactor plant modifications. The reactor remained shut down until April 1965, at which time operations were resumed.

A monitoring program was begun 2 years before plant startup to determine the background levels of radioactivity in the environment. This program was continued after plant startup to ensure that radioactive waste discharges from normal plant operations do not cause significant changes in these levels in the plant environment. The present program of monitoring consists of measurements of radioactivity in air, fallout, and Ohio River water. Figure 3 shows the sampling locations.

Liquid radioactive waste disposal

The concentration limits for the discharge of radioactive wastes at Shippingport are based on a knowledge of the radionuclide mixture making up the waste and on the radiation protection standards of Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524; and Chapter 4, Article 433 of the Rules and Regulations, Commonwealth of Pennsylvania Department of Health. The discharge of tritium, one of the less hazardous radionuclides, is controlled separately, based on its own limit. The liquid effluent from the plant radioactive waste disposal system is carefully monitored before, during, and after release to the Ohio River to ensure that the concentration limits recommended by the above regulations are not exceeded.

The liquid radioactive wastes discharged during the second half of 1965 are summarized below. The monthly average concentrations of gross radioactivity shown in table 7 include normal background radioactivity and are calculated after total radioactive waste discharges are diluted in the condenser cooling water effluent channel. The maximum total discharge, exclusive of tritium, in 1 day during the second half of 1965, was 4.65 mCi.

Table 7. Total radioactive waste, exclusive of tritium, discharged into the Ohio River during 1965

Period	Total discharge (mCi)	Average discharge per day (mCi)	Average concentration effluent channel (pCi/liter)
July	6.11	0.197	1.75
August	4.09	0.132	1.07
September	4.15	0.138	1.00
October	16.67	0.538	5.48
November	16.83	0.561	5.52
December	15.38	0.496	0.82
Total second half	63.2	0.344	1.74
Total first half	74.4	0.65	3.86
Total 1965	138	0.50	2.48

Table 8 is a summary of the tritium that was discharged into the Ohio River, the monthly average concentration of tritium in the hold-up tanks prior to discharge, and the monthly average concentration of waste in the effluent channel after dilution with the condenser cooling

Table 8. Tritium released to Ohio River during 1965

Period	Total discharge (mCi)	Average discharge (mCi)	Average concentration in holdup tank (pCi/liter)	Average concentration in effluent channel (pCi/liter)
July	227	7.32	1,510,000	115
August	135	4.35	5,100,000	85
September	190	6.34	1,690,000	195
October	626	20.2	2,660,000	716
November	867	28.9	3,380,000	420
December	916	29.6	3,540,000	50
Total second half	2,961	16.1	2,840,000	115
Total first half	81	0.447	520,000	10.9
Total 1965	3,042	8.34	1,680,000	88.8

---

[5] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the Second Half of 1965 and Calendar Year 1965," PNRO-SMD-137.

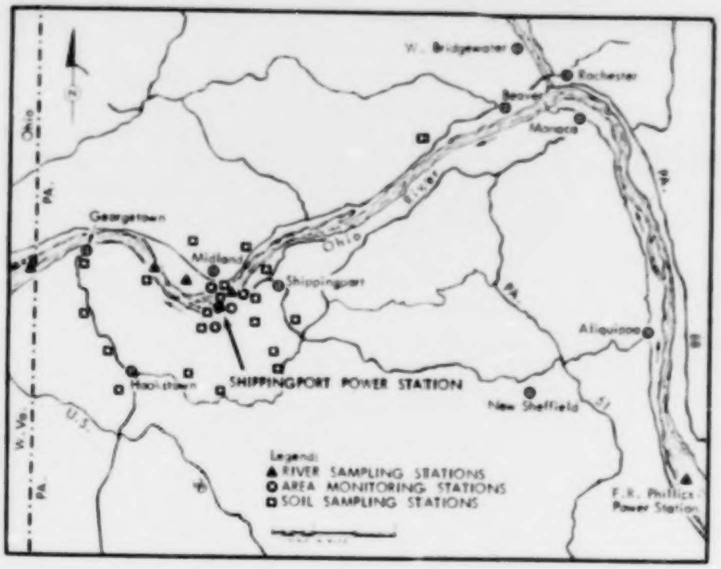
W. Bridgewater
Rochester
Beaver
Monaca
Ohio
PA.
Georgetown
Midland
Ohio
River
Shippingport
PA.
Aliquippa
SHIPPINGPORT POWER STATION
Hookstown
New Sheffield
W. Va.
PA.
U.S.
PA.
Legend:
▲ RIVER SAMPLING STATIONS
○ AREA MONITORING STATIONS
□ SOIL SAMPLING STATIONS
F.R. Phillips Power Station

Figure 3. Shippingport power station sampling locations

water. The maximum tritium discharged in 1 day during the second half of 1965 was 131 mCi. Automatic samplers are installed at the station's river water influent and effluent to collect river water samples continuously for comparative purposes.

Since the effluent sampler was inoperative during this report period, daily grab samples were collected. Weekly composites of the daily grab samples and continuous samples were analyzed for gross beta and gross alpha radioactivities in the suspended and dissolved solids. The potassium–40 radioactivity in the total solids of these samples was also measured. No significant difference was observed between the average alpha, beta, and potassium–40 radioactivity in the upstream and downstream samples. The results of these analyses are shown in table 9.

Atmospheric release of radioactive materials

During the second half of 1965, a total of 32.7 mCi of xenon–133 was released from Shippingport at concentrations less than the limit of 300,000 pCi/m^3. The incinerator, which is used for burning contaminated, combustible waste, was not operated.

Table 9. Gross radioactivity in the Ohio River during 1965

Type of radioactive material	Concentration, pCi/liter					
	Upstream samples			Downstream samples		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha						
Second half						
Suspended	0.98	0.02	0.20	3.71	0.03	0.30
Dissolved	5.20	0.33	1.13	4.75	0.33	1.27
Total	5.48	0.37	1.33	5.34	0.25	1.57
First half.........total..			1.78			1.56
Calendar year.....total..			1.56			1.57
Beta						
Second half						
Suspended	23.5	0.63	4.16	53.5	0.65	7.68
Dissolved	26.8	0.83	10.18	52.4	3.31	13.46
Total	50.3	4.77	14.34	73.2	4.32	21.12
First half.........total..			18.77			19.02
Calendar year.....total..			16.56			20.07
Potassium-40						
Second half.......total..	11.6	2.30	7.80	11.3	2.10	7.80
First half.........total..			3.75			4.10
Calendar year.....total..			5.78			5.95

Environmental monitoring

Three area monitoring stations are normally used to collect fallout, to detect and record levels of external beta-gamma radiation, and to detect and record levels of airborne particulate radioactivity in the power station vicinity. Stations 1, 2, and 3 are located 150 yards southeast, 150 yards west, and one-half mile north-northwest of the reactor building, respectively. At the beginning of this 6-month period, the equipment used for monitoring the levels of external radiation and airborne particulate radioactivity at station 2 was taken out of service. The remaining two stations include a continuously moving paper tape air sampler with an end-window Geiger-Mueller detector and a recorder. Since the radioactivity is measured by the detector only one-half hour after its collection, naturally occurring radon and thoron daughters are also included. The data collected by the stations are checked and averaged weekly. The 6-month averages of these data from stations 1 and 3 are listed in table 10.

Table 10. Airborne particulate radioactivity during 1965

Station number and period	Percent of time not working	Average concentration, pCi/m³		
		Maximum	Minimum	Average
1				
Second half	69	9.03	0.0785	2.12
First half				1.40
Calendar year				1.76
2				
Second half	100			
First half				2.52
Calendar year				2.52
3				
Second half	0	7.85	0.0785	1.71
First half				1.10
Calendar year				1.40

External beta-gamma radiation levels at each station are continuously measured and recorded by a Geiger-Mueller detector and a recorder. The data collected at each station are checked and averaged weekly. The results of these measurements, as shown in table 11, indicate that the radiation levels for stations 1 and 3 were not significantly different from the averages for these stations for previous years.

Table 11. Beta-gamma background radiation levels during 1965

Station number and period	Percent of time not working	Radiation levels, mR/hr		
		Maximum	Minimum	Average
1				
Second half	8	0.420	0.006	0.013
First half				0.016
Calendar year				0.015
2				
Second half	100			
First half				0.14
Calendar year				0.14
3				
Second half	0	0.059	0.011	0.021
First half				0.022
Calendar year				0.022

The radioactive fallout at each station was collected in pots over a 1-month period and analyzed for beta radioactivity. As shown in table 12, the 6-month averages for the stations did not differ significantly to indicate that any radioactivity was released by the power station.

Table 12. Beta radioactivity in fallout during 1965

Station number and period	Deposition rate, nCi/m²/month		
	Maximum	Minimum	Average
1			
Second half	7.16	1.79	4.28
First half			23.9
Calendar year			14.9
2			
Second half	6.78	2.55	4.21
First half			20.8
Calendar year			12.6
3			
Second half	7.60	3.89	4.40
First half			19.9
Calendar year			12.2

Average for all stations—second half—4.28 nCi/m²/month.

Summary

During the second half of 1965, measurements of radioactivity were made in the Ohio River and the atmosphere in the vicinity of the Shippingport Atomic Power Station. The results of these measurements indicate that the radioactive material released by the power station into the air and into the Ohio River did not result in a significant change in the existing levels of radioactivity in the environment.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	April 1962
July 1962–June 1963	March 1964
July–December 1963	November 1964
Calendar Year 1964	August 1965
January–June 1965	February 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, JUNE 1966

Five underground U.S. nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission during June 1966. The tests conducted on June 2 and 3 were of low-intermediate yield (force equivalent to 20–200 kilotons of TNT); tests conducted on June 10 and 25 were of low yield (force equivalent of up to 20 kilotons of TNT); and the test conducted on June 30 was of intermediate yield (force equivalent to 200 kilotons to 1 megaton of TNT).

The test of June 25 was part of the "Plowshare Program" to develop peaceful uses for nuclear explosives. This test was part of an experimental effort to develop a special nuclear device capable of producing in a nuclear explosion neutron-rich isotopes of the known transplutonium elements and, possibly, of new, heavier elements.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TRITIUM IN SURFACE WATERS, 1964–1965. *M. W. Chesnutt, J. C. Drobinski, Jr.,* and *R. H. Gorrie* (U.S. Public Health Service). *Radiological Health Data and Reports,* Vol. 7, July 1966, pp. 377–380.

Concentrations of tritium in U.S. surface waters are reported for the period of May 1964 through December 1965. This is the initial report of a continuing surveillance program. The results show some differences in tritium concentrations in water samples from various parts of the country and as a function of time. The highest level observed (20.3 nCi/liter) is well below the occupational exposure guide (30 μCi/liter) and the guidance level requiring active surveillance (100 nCi/liter), calculated from the general guidance of the Federal Radiation Council.

KEY WORDS: environment, exposure, guides, nuclear facilities, river systems, surface waters, tritium.

STRONTIUM-90 IN 1965 UNITED STATES WHEAT. *R. A. Anderson* and *V. F. Pfeifer* (U.S. Department of Agriculture). *Radiological Health Data and Reports,* Vol. 7, July 1966, pp. 381–382.

In continuing surveys of strontium-90 levels in wheat, USDA studies indicate the U.S. weighted average concentration to be 95 pCi/kg, which compared well with the Federal Radiation Council's prediction for 1965 (88 pCi/kg). The 1965 average also confirms the predicted continuing downward trend seen in 1963 and 1964 averages—220 and 133 pCi/kg, respectively. Samples used to develop the 1965 average represented 52 percent of the U.S. wheat production; and individual strontium-90 concentrations ranged from a low of 31 pCi/kg, in soft white winter wheat from Washington, to a high of 174 pCi/kg in hard red winter wheat from Kansas. It was noted that the 1965 trends of high and low concentrations were similar to those of 1964.

KEY WORDS: milled products, sampling, strontium-90, survey, United States, wheat.

STRONTIUM-90 IN HUMAN BONE FROM INFANCY TO ADULTHOOD, 1962–1963. *G. W. Gaffney, R. M. Hallisey, M. S. Miller,* and *E. J. Baratta* (Division of Radiological Health). *Radiological Health Data and Reports,* Vol. 7, July 1966, pp. 383–386.

Strontium-90 accumulation in the bones of children and adults through age 25 is analyzed by comparing the strontium-90 to calcium ratios found in specimens from selected age groups during the 1962–1963 portion of a continuing program. The highest mean strontium-90 to calcium ratios were found in the 1- to 4-year olds, with the 1962 peak in the 1-year olds (4.5 pCi/g) and the 1963 peak in the 2-year olds (5.6 pCi/g). It is pointed out that the mean values for the group under 1 year of age were relatively low (2.6 pCi/g in 1962; 1.8 pCi/g in 1963), but were obtained from a small number of samples. Average strontium-90 to calcium ratios in bone of older groups declined with increasing age and were least in the 20- to 25-year-age group. The data for each age group, although limited, appear to follow a log normal distribution, and it is suggested that this distribution is more suitable than a normal distribution as a basis for calculating the proportion of a population group in which a given body burden is unlikely to be exceeded.

KEY WORDS: adults, body burden, bone, children, human log normal distribution, population, strontium-90/calcium ratio.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 8 August 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
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Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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RADIOLOGICAL HEALTH DATA AND REPORTS

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● Division of Radiological Health

Reports

STRONTIUM-90 CONCENTRATIONS OBSERVED IN U.S. PASTEURIZED MILK COMPARED WITH STRONTIUM-90 LEVELS IN PRECIPITATION, IN TOTAL DEPOSITION, AND IN SOIL, 1960-1963

Henry L. Fisher, James R. Coleman, and *Richard D. Grundy*[1]

SYNOPSIS: Annual averages of strontium-90 concentrations in milk were compared with precipitation, strontium-90 deposition, and strontium-90 in soil for the years 1960-1963 on the basis of linear relationship. This relationship may be useful for limited predictions of future strontium-90 concentrations in milk. As expected, higher concentrations of strontium-90 were found in milk from areas of higher concentrations of strontium-90 in soil, and higher milk concentrations seemed to be associated with increased rainfall. Although it was clear that increased deposition of strontium-90 was related to its concentration in milk, variations in the relationship remain to be studied on the basis of the specific transport mechanisms involved.

The Public Health Service's Pasteurized Milk Sampling Network (PMN) has been in operation since 1960. The data obtained from this network are routinely published in *Radiological Health Data and Reports* and have been recently summarized (*1, 2*). The purpose of this review is to relate the strontium-90 concentrations observed in milk with such parameters as precipitation, strontium-90 deposition, and strontium-90 concentration in soils. Although these parameters have served in the development of rather detailed prediction models (*3, 4*), only general comparisons will be made here, and comparisons for periods of time of less than one year will not be attempted. More detailed investigations relating to these parameters are currently in progress.

Annual precipitation

The average concentration of strontium-90 in milk and the total annual precipitation for each of the years 1960-1963 (*5*), are shown in figures 1 and 2, respectively. Using these data, the PMN stations were separated into three groups. Group One stations were located in an area where annual precipitation ranges from 0 to 16 inches, Group Two stations were located in areas where precipitation ranges from 16 to 32 inches, and Group Three stations were located in areas where precipitation ranges from 32 to 64 inches. For each of these groups, distributions of stations versus annual average strontium-90 concentration in milk were constructed and are shown in table 1.

Studies have shown that strontium-90 deposition is correlated with precipitation (*6-8*). The concept of "wet" areas (areas of greatest annual precipitation) and "dry" areas has been used with success to relate the strontium-90 content of milk and the total diet to the amount of annual precipitation (*9-10*). Comparison of average strontium-90 concentrations in milk to annual precipitation (table 1) for 1960-1963 indicates that the higher annual average strontium-90 content of milk is associated with greater annual precipitation or at least is associated with areas which have the higher annual precipitation.

---

[1] At the time of the preparation of this paper, Mr. Coleman was chief, Data Collation and Analysis Section, Radiation Surveillance Center, DRH, PHS, Washington, D.C., and Mr. Grundy and Mr. Fisher were staff members.

56

Table 1 also shows that not every station in a high precipitation area will have a high annual strontium-90 average. Likewise, every station in a low precipitation area will not necessarily have low annual average strontium-90 concentrations in milk. This point calls attention to the fact that there are other operative factors than the total amount of precipitation which influence strontium-90 concentrations in milk. Such factors include the height of the precipitation cloud, the precipitation generation and growth mechanism in the

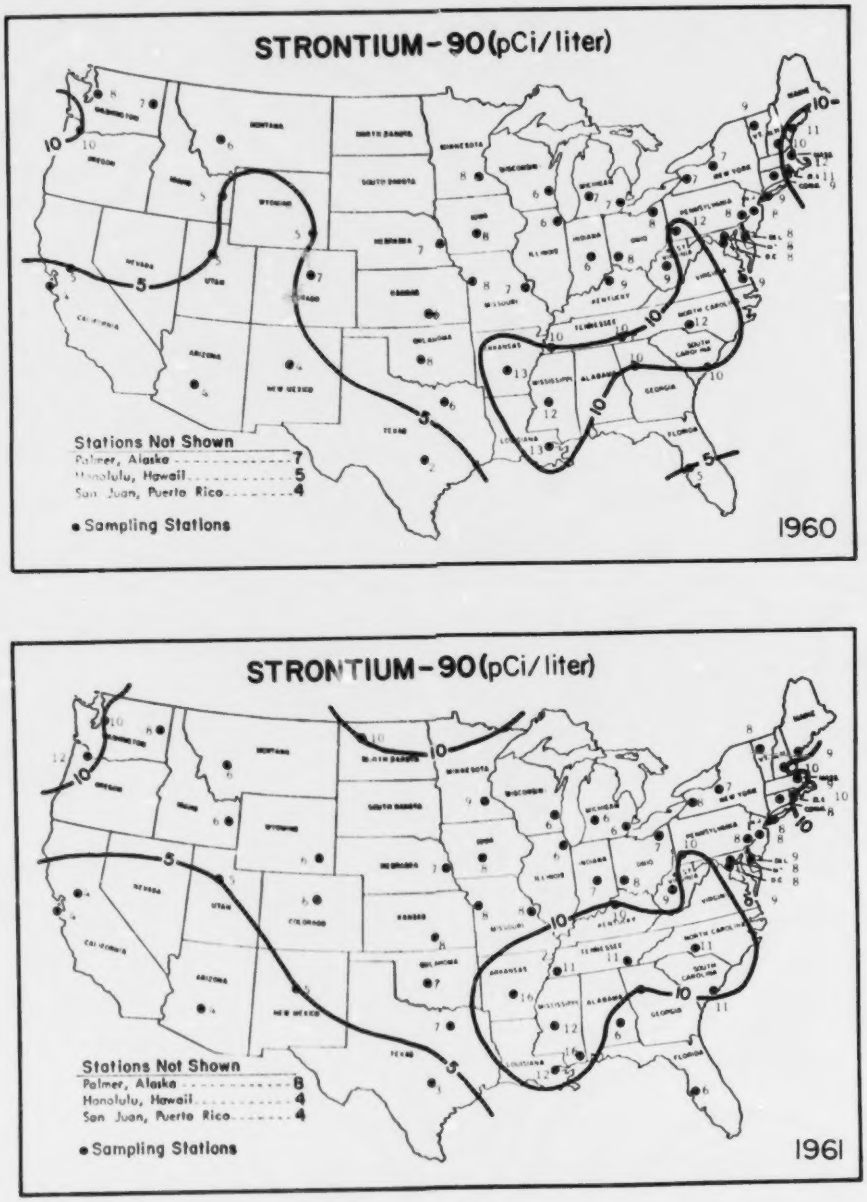

STRONTIUM-90(pCi/liter)
Stations Not Shown
Palmer, Alaska 7
Honolulu, Hawaii 5
San Juan, Puerto Rico 4
• Sampling Stations
1960
STRONTIUM-90(pCi/liter)
Stations Not Shown
Palmer, Alaska 8
Honolulu, Hawaii 4
San Juan, Puerto Rico 4
• Sampling Stations
1961

Figure 1. Annual average strontium-90 concentrations in milk, 1960–1963

clouds, and the amount and characteristics of the radioactive aerosols initially in the air versus participating in the precipitation process (*11*). It is reasonable to assume that variation in the growth of forage as a result of the amount of precipitation and relative soil richness is a contributing factor.

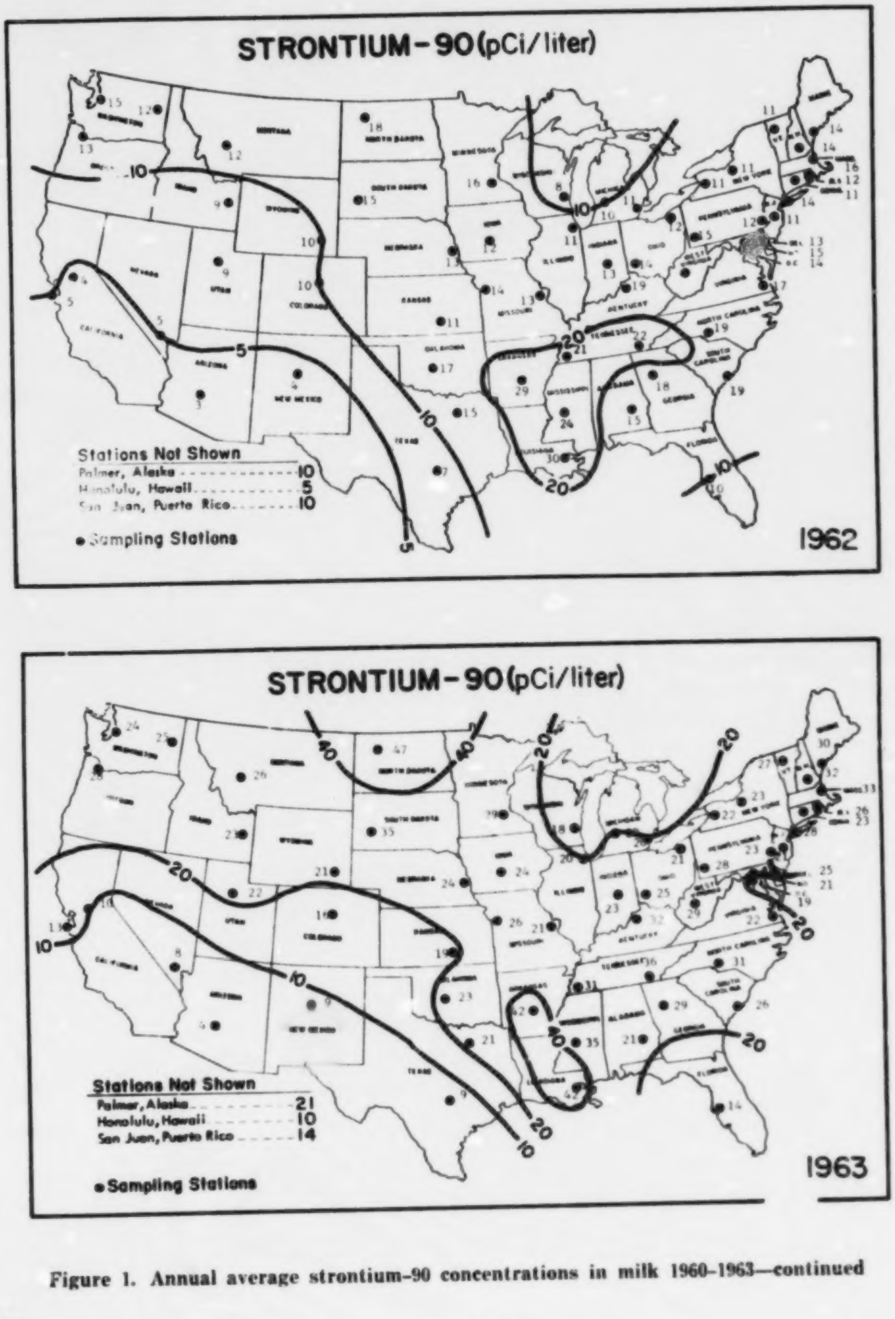

STRONTIUM-90 (pCi/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii 5
San Juan, Puerto Rico 10
• Sampling Stations
1962
STRONTIUM-90 (pCi/liter)
Stations Not Shown
Palmer, Alaska 21
Honolulu, Hawaii 10
San Juan, Puerto Rico 14
• Sampling Stations
1963

Figure 1. Annual average strontium-90 concentrations in milk 1960-1963—continued

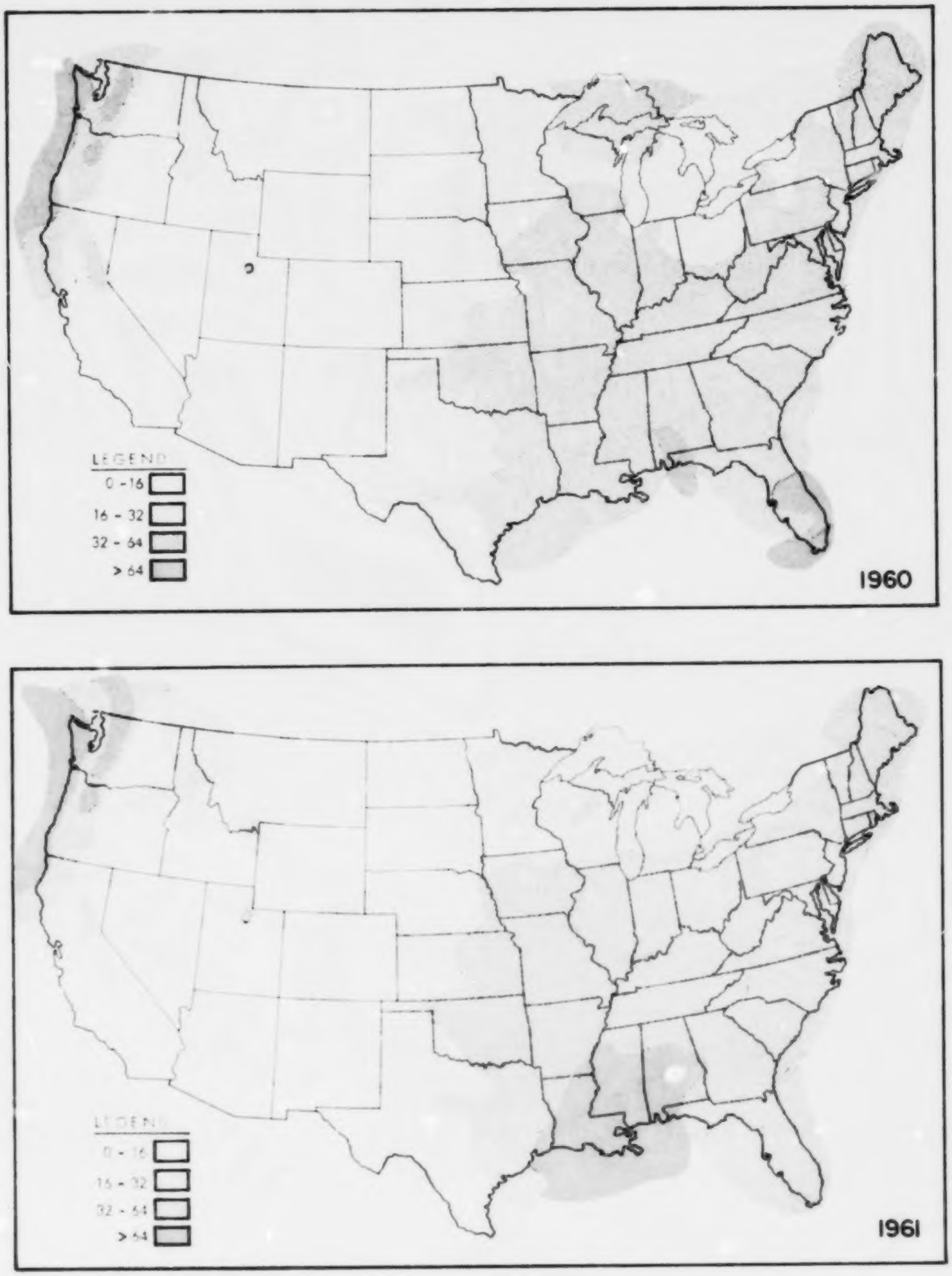

LEGEND
0 - 16
16 - 32
32 - 64
> 64
1960
LEGEND
0 - 16
16 - 32
32 - 64
> 64
1961

Figure 2. Total annual precipitation (inches), 1960–1963

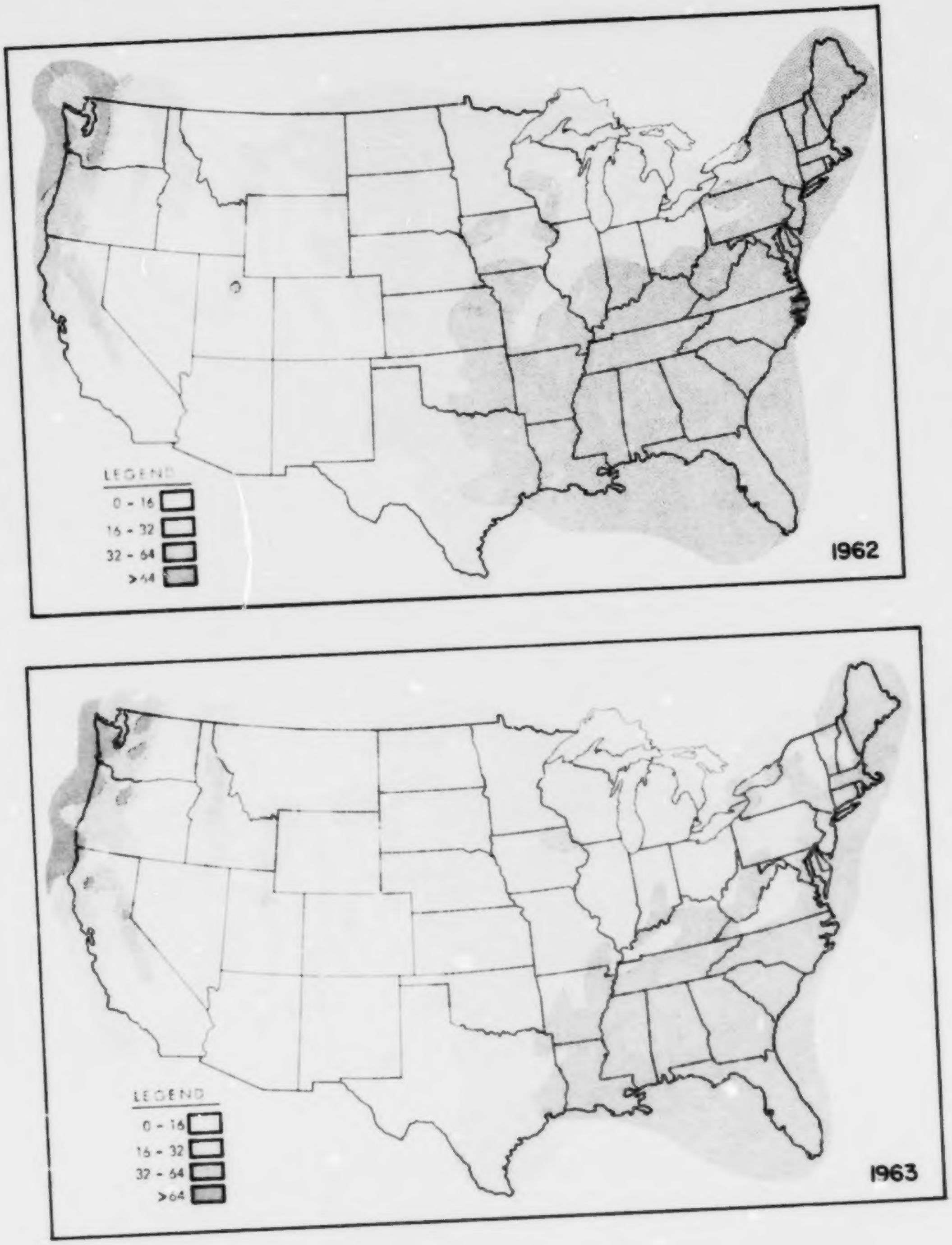

LEGEND
0 - 16
16 - 32
32 - 64
>64
1962
LEGEND
0 - 16
16 - 32
32 - 64
>64
1963

Figure 2. Total annual precipitation (inches), 1960-1963—Continued

Table 1. Percental frequency distribution of PMN stations according to strontium-90 concentrations in milk for three ranges of total annual precipitation

Year and range of precipitation (inches)	Strontium-90, pCi/liter									
	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49
1960										
0–16	[a] 4(2)	9(5)								
>16–32	2(1)	18(10)	2(1)							
>32–64	2(1)	40(22)	24(13)							
1961										
0–16	5(3)	7(4)	2(1)							
>16–32		11(6)								
>32–64	2(1)	[b] 49(28)	[c] 23(13)	2(1)						
1962										
0–16	3(2)	3(2)	3(2)							
>16–32	2(1)	3(2)	16(9)	7(4)						
>32–64		2(1)	31(18)	21(12)	5(3)	2(1)	2(1)			
1963										
0–16	2(1)	3(2)		2(1)		2(1)				
>16–32		2(1)	3(2)	3(2)	20(12)	10(6)	2(1)	2(1)		2(1)
>32–64			2(1)	2(1)	17(10)	12(7)	8(5)	3(2)	3(2)	

[a] Values in parenthesis are number of stations.
[b] One station in this group had rainfall greater than 64 inches.
[c] Two stations in this group had rainfall greater than 64 inches.

Strontium–90 deposition, 1960-1963

The AEC's Health and Safety Laboratory (HASL) has analyzed strontium–90 fallout monthly at 27 different locations throughout the conterminous United States from 1960–1963 (*12*). The annual total strontium–90 depositions at these locations were obtained from the HASL data and are shown on the map in figure 3 as isoconcentration lines. Although local fallout variations may result in differences from these contour maps, the value at each station is the sum of 12 completely independent samples and analyses and represents the best available data with which to derive such contours.

Table 2. Percental frequency distribution of PMN stations according to annual average strontium-90 concentrations in milk for various ranges of total annual strontium-90 fallout deposition

Year and range of ^{90}Sr deposition, mCi/mi^2	Strontium-90 in milk, pCi/liter										
	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	Avg.
1960											
0–4	[a] 7(4)	35(19)	9(5)								6.9
>4–8		33(18)	16(9)								9.0
1961											
0–4	7(4)	12(7)	2(1)								5.6
>4–8		54(31)	21(12)	2(1)							8.7
>8–12			2(1)								10.0
1962											
>8–12	3(2)		2(1)								5.7
>12–16	2(1)	3(2)	3(2)								11.0
>16–20		3(2)	12(7)	12(7)							13.7
>20–24			28(16)	7(4)	5(3)	2(1)					15.1
>24–28			2(1)	9(5)							15.8
>28–36		2(1)	3(2)								10.7
1963											
>8–16	2(1)	5(3)			2(1)						10.2
>16–24			3(2)	2(1)	2(1)				2(1)		20.8
>24–32				2(1)	7(4)	7(4)	2(1)	3(2)	2(1)	2(1)	28.8
>32–40				2(1)	5(3)	7(3)	3(2)	2(1)			26.6
>40–48			2(1)		8(5)	3(2)					22.1
>48–56				2(1)	7(4)	2(1)					21.8
>56–64					7(4)	5(3)	5(3)				26.6

[a] Values in parenthesis are number of stations.

To develop a distribution of strontium-90 deposition versus annual average strontium-90 concentrations in milk, the following procedure was employed: the strontium-90 deposition was divided into a number of ranges, and the PMN stations which were situated in each range according to figure 3, were tabulated. For each of these sets, a distribution of stations versus annual average strontium-90 in milk concentrations was developed. The resulting compound station distributions may be seen in table 2.

These distributions are shown graphically in figure 4. Each vertical bar is plotted at the midpoints of the milk concentration and deposition intervals. A smoothed curve connects

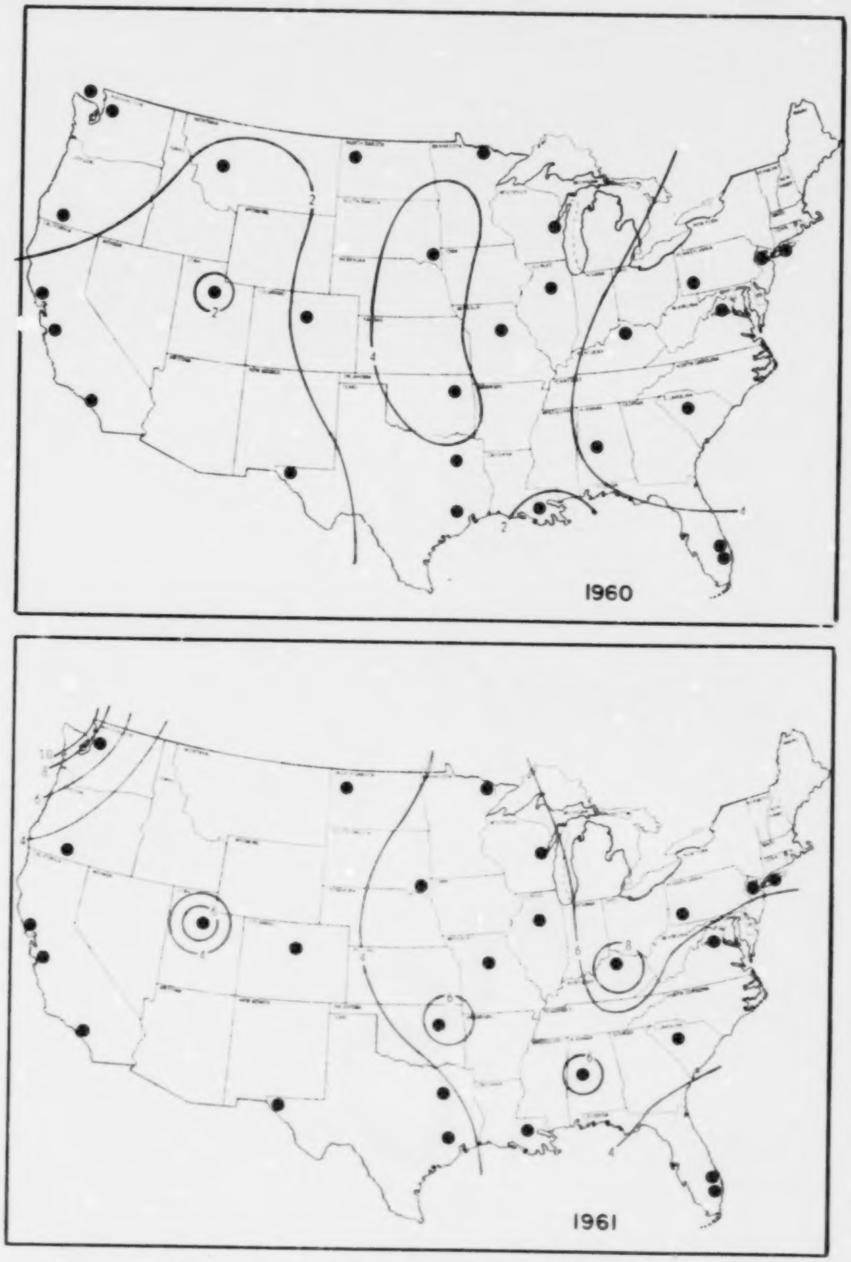
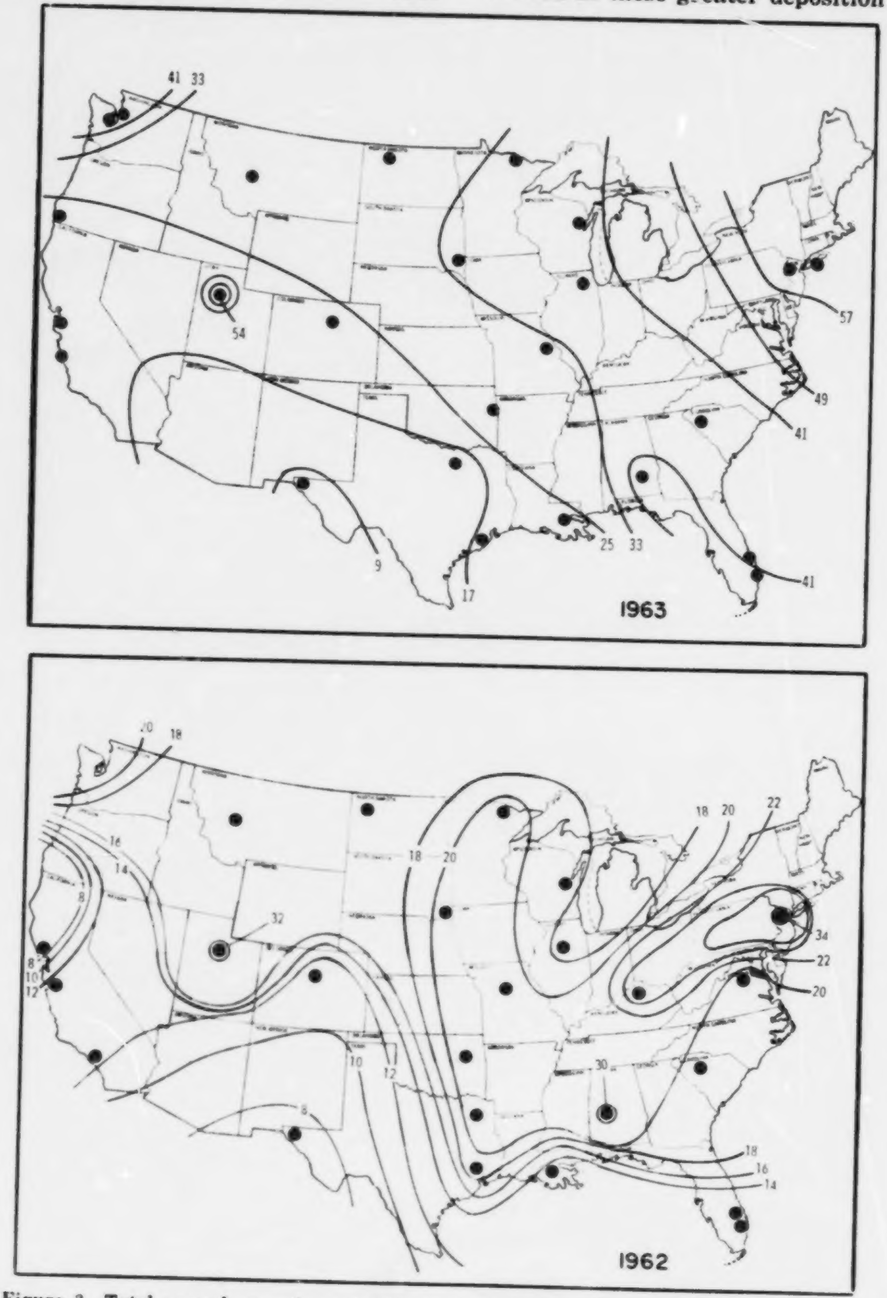


Figure 3. Total annual strontium-90 fallout deposition (mCi/mi²) 1960–1963

the tops of the bars to provide an indication of the continuous distribution in the plane of fixed deposition. The compound distribution would be a smoothed surface passing through the curves shown.

Figure 4 indicates that the dispersion of strontium-90 levels in milk was small in 1960 and 1961. Strontium-90 deposition in 1962 and 1963 was much greater than in 1960 and 1961 (see figure 3). Increased annual average strontium-90 concentration in milk is associated with increased total average strontium-90 deposition, but much more variability in milk levels is seen at these greater deposition levels (*13*).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1962

Figure 3. Total annual strontium-90 fallout deposition (mCi/mi²) 1960-1963—continued

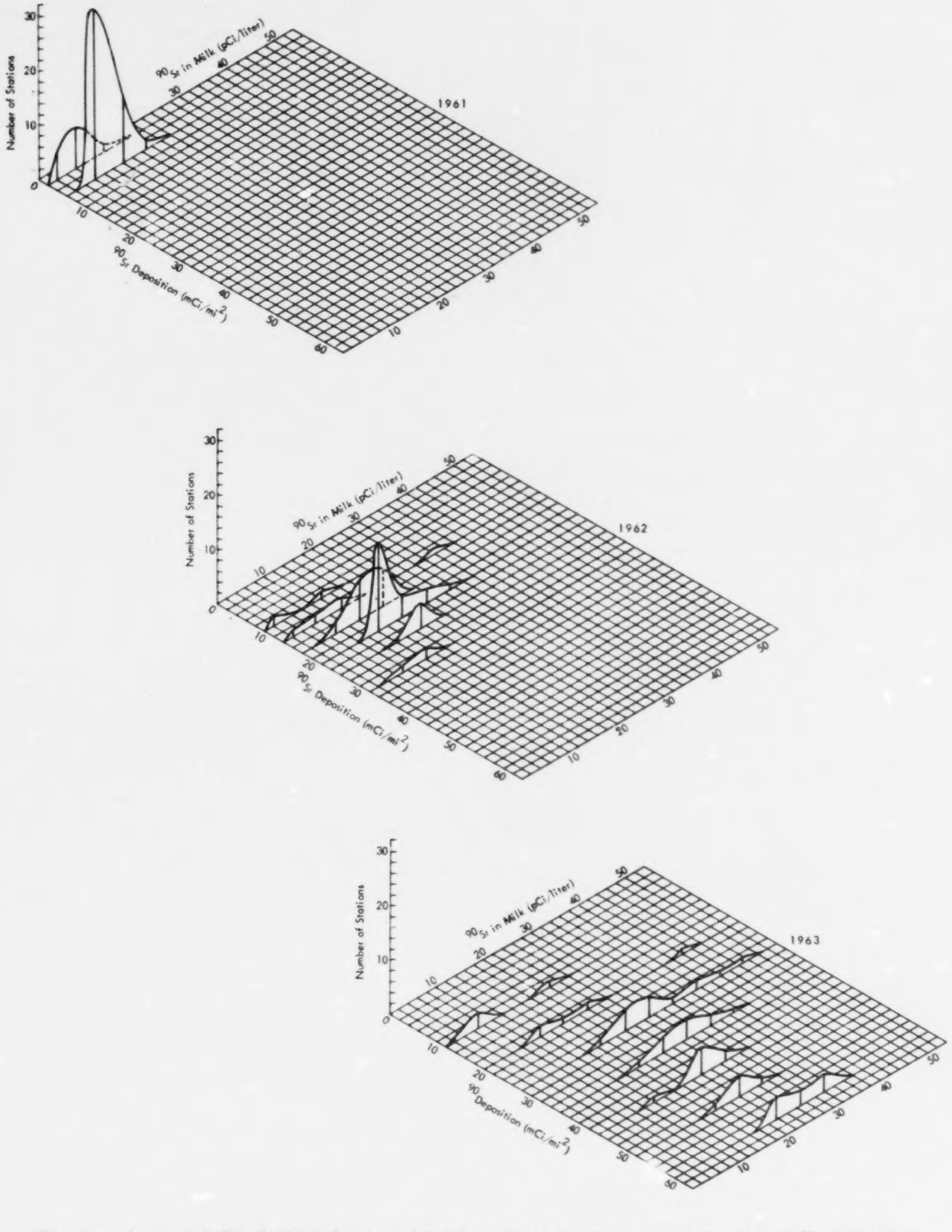
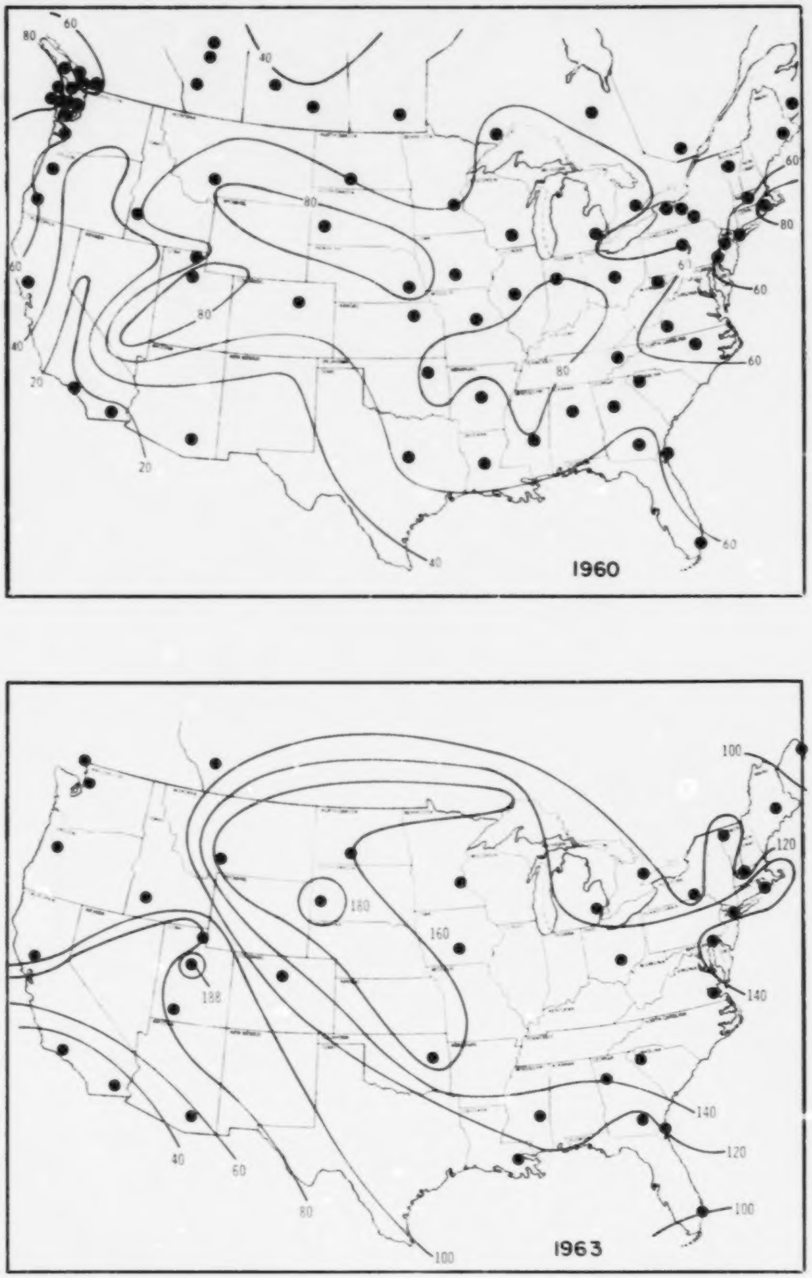


Figure 4. Compound distributions for strontium-90 in deposition versus strontium-90 in milk, 1961–1963

Strontium-90 in soil

Figure 5 portrays available information on the strontium-90 content of soil in 1960 and 1963 (*14, 15*). Using these maps, the milk network stations were arbitrarily grouped into two categories. For 1960 the stations in the first group were those appearing in an area of less than 60 mCi/mi² determined from figure 5. The stations in the second group were in an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100
100
1963

Figure 5. Strontium-90 in soil (mCi/mi²) in conterminous United States and southern Canada in 1960 and 1963

area with a soil level of greater than or equal to 60 mCi/mi^2. For 1963, the two groups were less than 140 mCi/mi^2 and greater than or equal to 140 mCi/mi^2. For each set of stations, a percentage distribution of these stations according to various ranges of annual average strontium-90 concentrations in milk was developed. These results are shown in table 3. It may be seen that there are only small differences between the distributions for high and low soil content for either year. This supports the concept that recent strontium-90 deposition is more effective in influencing the strontium-90 concentration in milk than the translocation of strontium-90 from the soil (*16*).

Table 3. Percental frequency distribution of PMN stations according to concentrations of strontium-90 in milk for two groups of the strontium-90 content of soil, 1960 and 1963

1960			1963		
Range of ^{90}Sr in milk (pCi/liter)	^{90}Sr in soil <60 mCi/mi^2 (percent)	^{90}Sr in soil ≥60 mCi/mi^2 (percent)	Range of ^{90}Sr in milk (pCi/liter)	^{90}Sr in soil <140 mCi/mi^2 (percent)	^{90}Sr in soil ≥140 mCi/mi^2 (percent)
0-2	5 [a](1)	3 (1)	0-4	4 (1)	
>2-4	17 (3)	11 (–)	5-9	11 (3)	
>4-6	11 (2)	21 (8)	10-14	11 (3)	
>6-8	39 (7)	34 (13)	15-19	4 (1)	10 (3)
>8-10	22 (4)	24 (9)	20-24	40 (11)	34 (11)
>10-12	6 (1)	13 (5)	25-29	15 (4)	31 (10)
>12-14		5 (6)	30-34	7 (2)	13 (4)
			35-39	4 (1)	6 (2)
			40-44	4 (1)	3 (1)
			45-49		3 (1)
Average (pCi/liter)	7.0	8.3	Average (pCi/liter)	21.0	26.8

[a] Numbers in parentheses are number of stations.

Least squares analysis of strontium-90 content of milk, soil, and deposition

There are a number of factors which apparently influence the strontium-90 content of milk. However, as indicated previously, a relationship may exist between strontium-90 concentration in milk and several of the more prominent factors mentioned. It has been previously suggested that for a given area the strontium-90 content of milk can be related linearly to the strontium-90 deposition and the strontium-90 content of soil (*3, 17*). Using this concept, an equation may be written:

$$M_i = aD_i + bS_i \qquad (1)$$

where

M_i = strontium-90 concentration in milk (pCi/liter),
D_i = annual strontium-90 fallout deposition (mCi/mi^2),
S_i = strontium-90 content of soil (mCi/mi^2),
and "a" and "b" are constants.

Using the data on the strontium-90 content of soil for 1960 and 1963 in figure 5 and the strontium-90 deposition for 1960 and 1963 in figure 3, each PMN station was assigned a strontium-90 soil level and an annual strontium-90 deposition for the years 1960 and 1963. These data, along with the annual average strontium-90 concentration in milk at each PMN station for 1960 and 1963, were used to determine, by least squares analysis, the constants "a" and "b" in equation 1. The root mean square (σ_r) deviation of the annual average strontium-90 concentration observed in milk (M_i) from the calculated values (M_i) for both 1960 and 1963 was also determined. The result of these calculations is given by:

$$\mathit{M}_i = 0.16D_i + 0.13\ S_i \qquad i = 1, \ldots, 114 \qquad (2)$$

(1960 and 1963 data)

and yield σ_r (1960) and σ_r (1963) of 3 and 6 pCi/liter, respectively.

These results may be compared with the values reported by the U.N. Scientific Committee (*16*) after conversion of units. Given in terms of mCi/km^2 and pCi/g Ca, the values of "a" and "b" calculated above are 0.35 and 0.29, respectively (assuming a milk calcium concentration of 1.18 g/liter). The worldwide range of values of "a" reported in the above reference (on the basis of 1960 data) is from 0.3 to 1.5, with an average of 0.78. The U.S. value was 0.7. Similarly, values of "b" range from 0.21 to 0.80, with an average of 0.37. The U.S. value was 0.27.

It is interesting to identify the stations in which the calculated milk result was different from the observed annual average by $2\sigma_t$ or more. In 1960, the $2\sigma_t$ value was 6 pCi/liter, and these stations and their associated $\mathrm{M_i}$-M_i are as follows:

Station	$\mathrm{M_i}$-M_i
Indianapolis, Indiana	–6
Omaha, Nebraska	–6
Salt Lake City, Utah	–7

In 1963, the 2σ value was 14 pCi/liter and these stations and their associated $\mathrm{M_i}$-M_i are as follows:

Station	$\mathrm{M_i}$-M_i
Little Rock, Arkansas	18
New Orleans, Louisiana	25
Minot, North Dakota	21

Although the sign variation in $\mathrm{M_i}$-M_i from 1960 to 1963 could be the result of chance, the change is significant and shows a tendency to overestimate 1960 values and underestimate 1963 values. This would seem to imply that the effect of deposition has been underestimated and the effect of soil levels overestimated. It is more likely that these stations could have very different "a" and "b" factors from the other stations, or that the method of determining strontium–90 fallout levels and soil levels at each milk sampling station based on contour map interpolation has introduced the variations. It is always possible that month-to-month variations in the strontium–90 deposition may introduce additional inaccuracy, since the analysis used in this paper is based on yearly time intervals. In spite of these difficulties, this approach is reasonable in terms of obtaining results within the limits of error stated.

The U.S. Weather Bureau predicted the annual strontium–90 fallout deposition for 1964 and 1965 (*8*). These values are 10 mCi/mi^2 (range 5 to 25) for 1964 and 5 mCi/mi^2 (range 3 to 15) for 1965, and an average soil level of 140 mCi/mi^2 (range 60 to 180) for 1963. The average strontium–90 concentration in milk in the United States from equation 2 in 1964 and again in 1965 would be approximately 20 pCi/liter in both 1964 and 1965. The observed range for 1964 was 4 to 54 pCi/liter with an average of 25 (*1*), while the observed range for 1965 was 5 to 42 pCi/liter, with an average of 17.5 pCi/liter. These values again point out the failure of the parameter to predict closely the range of observations but yielding a reasonable value for the average. Assuming negligible strontium–90 fallout after 1965, the average strontium–90 concentration in milk in 1966 would be 19 pCi/liter and thereafter would decrease at the same rate as the soil level. However, any strontium–90 deposition resulting from atmospheric testing since the limited test ban treaty would tend to raise this value.

Summary and discussion

This report has discussed the annual variation of strontium–90 in milk as related to precipitation and strontium–90 in deposition and in soil. For ease of analysis, each of these factors was first examined alone in relation to radionuclide levels in milk. However, it should be pointed out that milk sampled by the PMN is that distributed in an area. Therefore, milk shipped into an area from other locations would be expected to affect the correlation with fallout in the area sampled. Although such effects are assumed to be small, they are factors contributing to unexplained variability.

As expected, higher milk levels occurred generally in those areas where soil levels were greater, although this was not universally the case. Higher milk levels also seemed to be associated with increased precipitation.

Strontium–90 fallout deposition was compared with the annual average strontium–90 concentrations in milk. Although the expected effect that increased deposition relates to increased milk levels was apparent, there still were unexplained variations which suggest that other factors must be considered if an accurate description of strontium–90 concentrations in milk is to be found.

The strontium–90 concentrations in milk were assumed to be related to both the strontium–90 content of soil and strontium–90 deposition. Although only approximate, the results based on this relationship could possibly be used for limited predictions of future strontium-90 concentrations in milk (provided strontium-90 soils levels and strontium-90 deposition can be predicted), as well as providing insight into the relative influence of deposition and soil levels on milk concentration.

It is emphasized that this review is of a general type, based on annual parameters for a large area (the United States), and is not intended to prove or disprove the validity of specific mechanisms of radionuclide behavior in the environment. Such parameters as fallout and weather over short periods of time, microgeographical variation in strontium-90 in soil, and farming practices would undoubtedly explain many of the apparent temporal and geographical anomalies of strontium-90 concentrations in milk when considered on a regional or national scale.

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RADON-222 IN NATURAL GAS

Louis A. Bunce and *Frank W. Sattler*[1]

SYNOPSIS—In the preoperational phase of a study to determine the effect of an underground nuclear detonation on radon levels in natural gas, baseline levels of radon–222 have been measured during 1965 in natural gas from 307 producing wells in the proposed test area. Average radon–222 levels in natural gas from formations sampled varied from 2.7 to 66.9 pCi/liter, with a maximum observed value of 158.8 pCi/liter. Assuming combustion in a room without discrete ventilation radon–222 buildup from an original fuel concentration of 50 pCi/liter could produce a room concentration of 1 pCi/liter in the New Mexico area where the gas would be used. This estimated concentration equals the maximum exposure level permitted by regulations of the State of New Mexico (based on NCRP limits) under conditions on continuous or general population exposure. Normal use of natural gas would not be expected to produce radon–222 concentrations in excess of these recommended limits.

Radon–222[2] has been measured in natural gas from wells in northwestern New Mexico and southwestern Colorado, jointly by personnel of the U.S. Public Health Service and the El Paso Natural Gas Company. The purpose of this study was to establish baseline levels of radon–222 in natural gas in this area prior to initiation of "Project Gasbuggy" (*1*), a proposed underground nuclear detonation planned by the Atomic Energy Commission and the El Paso Natural Gas Company aimed at increasing productivity of a low-flow gas reservoir.

In 1963, 10 pCi/liter of radon–222 was observed in the natural gas supply to the Public Health Service Laboratory at Farmington, New Mexico. Because the radon–222 is a naturally occurring radionuclide which contributes to background radiation, and its presence in natural gas represents a possible source of radiation exposure to humans as well as a source of interference in low-level radiometric analyses, the laboratory staff decided to obtain further information on the radon content of natural gas in the area. The El Paso Natural Gas Company was asked to collaborate on this project and agreed to do so.

When Project Gasbuggy was proposed, the authors, anticipating that the detonation might affect radon levels in natural gas in the area, enlarged the project to include measurement of radon–222 levels in gas both before and after Project Gasbuggy.

The joint venture began in 1965. This report contains results of the initial series of gas analyses. There is no definite date for Project Gasbuggy at present; however, subsequent to the test, the Public Health Service and the El Paso Natural Gas Company plan again to assay the natural gas in the area to determine the effects of the detonation on radon–222 levels.

Procedure

During 1965, gas samples were collected by the El Paso Natural Gas Company personnel from 307 producing wells, principally in the Mesaverde, Pictured Cliffs, and Dakota Formations of the San Juan Basin in northwestern New Mexico and southwestern Colorado. Samples were collected at the well heads in metal cylinders containing approximately 0.75 liter. The sample cylinders were tagged with the well number, location, sample time, and date.

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[2] Radon–222 is a heavy gaseous radionuclide formed by the radioactive decay of radium-226. It has a half-life of 3.8 days and decays by emission of an alpha particle.

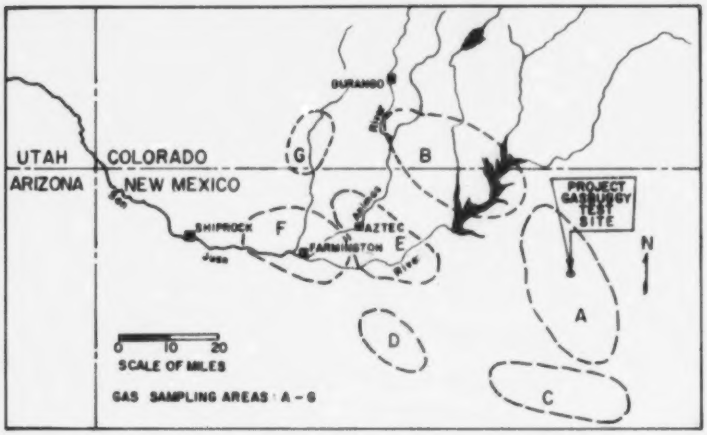

Figure 1. Natural gas sampling locations in the San Juan Basin

Samples were analyzed for radon–222 in the Public Health Service laboratory in Farmington, operated under contract with the New Mexico State Department of Health. Radon–222 was determined by alpha scintillation counting using a modification method described by Lucas (2). Gas samples were stripped of daughter products by bubbling through a weak acid solution, then were dried and transferred to the counting chamber. After aging for 4 hours, samples were counted and corrected for daughter ingrowth. Correction was also made for use of natural gas in lieu of nitrogen as the carrier gas.

Results

Table 1 presents the radon–222 levels found in natural gas samples collected from different geological formations in the areas shown in figure 1. All radon–222 values are corrected to the time of sample collection at the well head.

The radon–222 levels varied from a low of 0.2 pCi/liter of gas to a high of 158.8 pCi/liter. The radon–222 content in the Dakota formation showed very little variation from area to area. The mean radon–222 levels in this formation ranged from 9.1 pCi/liter in area A to 12.1 pCi/liter in area E. Only 8 of the 75 wells

Table 1. Radon-222 levels in natural gas, 1965

Area[a]	Formation	Number of wells sampled	Well depths, feet		Radon-222 level, pCi/liter		
			Mean	Range	Mean	Maximum	Minimum
A	Mesaverde	55	6,268	5,686–6,924	26.1	55.2	0.3
	Dakota	7	8,011	7,798–8,330	9.1	14.0	4.4
	Pictured Cliffs	26	4,241	3,860–4,572	14.5	26.9	0.2
B	Mesaverde	64	5,731	5,133–6,615	32.3	158.8	5.9
	Dakota	36	7,930	7,346–8,363	10.3	23.0	2.2
	Fruitland	11	2,655	2,293–3,054	2.7	12.9	0.5
C	Pictured Cliffs	16	3,137	2,062–3,850	66.9	158.8	12.8
D	Dakota	6	6,655	6,196–6,974	11.9	25.7	4.4
	Pictured Cliffs	6	2,216	1,721–4,021	56.2	115.6	6.4
	Gallup	5	6,057	5,503–6,289	22.4	33.9	12.1
E	Mesaverde	22	4,722	3,318–5,056	21.4	34.5	5.4
	Dakota	8	6,854	6,538–7,696	12.1	16.1	8.0
	Pictured Cliffs	9	2,496	2,180–3,310	38.6	65.1	11.5
F	Dakota	18	6,431	6,097–7,211	9.3	20.7	3.4
	Pictured Cliffs	5	2,178	960–3,[illegible]78	41.5	73.8	21.9
	Fruitland	5	1,481	978–1,774	30.7	42.4	5.4
G	Paradox	8	9,138	8,680–9,552	21.0	62.1	5.4

[a] Lettered areas shown in figure 1.

sampled in this formation showed radon levels greater than 20 pCi/liter, with the highest being 25.7 pCi/liter. The Mesaverde Formations showed a similiar consistency in mean radon–222 levels (Areas A, B, and C), although a wider range of concentrations (0.3 to 158.8 pCi/liter) was observed.

On the other hand, in the Pictured Cliffs Formation, samples from wells in area A averaged 14.5 pCi/liter radon–222, while those from areas C and D averaged 66.9 and 56.2 pCi/liter, respectively. Samples from this formation in areas E and F averaged 38.6 and 41.5 pCi/liter radon–222.

Table 2 shows the radon–222 levels found in the gas supplied to the radiological laboratory at Farmington. The values are for grab samples collected at the laboratory gas outlet in July 1963 and on 6 days in October 1965. The radon–222 level was much higher in October 1965 than in the summer of 1963[1].

Eleven wells were sampled twice, with a 3-month interval between. Table 3 shows the variation in radon–222 levels observed in each well. In each case, concurrent gas samples were collected from these wells by El Paso Natural Gas Company and analyzed chemically. The carbon dioxide nitrogen, and hydrocarbon content in the gas of both samples from each well were essentially the same, but some variations in radon–222 concentrations were observed in different samples from a given well. It is likely that the gas flow from a well at the time of sampling has a significant effect on the radon–222 content. A radon–222 profile on a well, developed over the period of a year under different production conditions, should be quite useful in evaluating radon–222 variation and the effect of gas flow rate on radon–222 buildup.

Table 2. Radon-222 in natural gas at Farmington laboratory

Date	Radon-222 (pCi/liter)
July 1963	10.0
October 1965	48.8
	53.0
	49.4
	50.6
	51.0
	52.6
Mean, six October grab samples	50.9

Table 3. Variation of radon-222 within gas wells

Formation	Well number	Sample taken (1965)	Radon-222 level (pCi/liter)
Mesaverde (Area A)	70-813	July	20.0
		October	11.4
	70-814	July	22.2
		October	0.8
	71-335	July	30.6
		October	15.7
	72-5[illegible]1	July	31.4
		October	79.1
Pictured Cliffs (Area A)	70-736	June	17.8
		September	14.8
	71-172	June	14.3
		September	11.9
	71-329	July	12.4
		October	8.9
	71-988	July	26.5
		October	25.5
	71-995	July	7.5
		October	9.1
Paradox (Area G)	75-036	May	51.2
		August	3.1
	76-170	May	13.1
		August	16.0

Evaluation of possible hazard to humans

Radon–222 levels in air as a result of burning natural gas can be compared to the maximum limits recommended by the International Commission on Radiological Protection (ICRP) and to the regulations of the State of New Mexico.

The maximum expected buildup of radon–222 would likely occur in a closed room containing unvented gas appliances (such as a large burner, a gas range with oven, or an unvented space heater). Since the natural gas produced in this area is predominantly methane, combustion of 1 liter of the gas will produce approximately 1 liter of carbon dioxide. Therefore, the radon-222 buildup from burning gas in a closed area would be proportional to that of carbon dioxide.

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[1] It appears likely that the difference observed might be explained by several variables, including changes in rate of gas usage and relative depletion of reservoirs. Obviously, different concentrations would result if different wells were used as sources of the gas, but this could not be verified for the periods studied. The El Paso Natural Gas Company normally commingles gas from the Pictured Cliffs, Dakota, and Mesaverde formations before the gas leaves the San Juan Basin. Another company operating in this general area—the Southern Union Gas Company—also commingles gas from various formations.

Normal ventilation in an occupied room would probably be such that the carbon dioxide level in the room air would not rise above 2 percent.[1] Thus, the radon-222 level in the room would not be expected to rise above 2 percent of its original concentration in the unburned gas. This would be 1 pCi/liter, assuming an original radon-222 concentration of 50 pCi/liter, the level observed in the gas at the laboratory at Farmington, New Mexico.

The upper limit recommended by the ICRP for continuous radon-222 exposure in air for the general population is 0.33 pCi/liter (*3*). The State of New Mexico regulations (*4*) are based on the report of the National Committee on Radiation Protection (*5*), which recommends an upper limit of 1 pCi/liter radon-222 in air to which large populations are continuously exposed outside of controlled areas. Thus, even assuming the extremely unfavorable conditions stated, the radon-222 level would not exceed the State's limit.

Although the estimated radon-222 concentrations added to the air under these conditions would approximate the NCRP recommended limit for continuous exposure to the general population, this situation would be neither continuous nor general. It would likely occur only in limited populations since any appreciable transmission time from well to consumer would decrease the radon-222 content at a rate of 50 percent every 3.8 days. In addition, exposure would not be continuous, but would be limited to time spent indoors. Under normal conditions, where the gas flame itself is vented in accordance with State regulations, accumulation of radon-222 would be expected to be considerably smaller than the estimated levels.

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[1] Assuming that the gas flame itself is properly vented as generally required by State regulations.

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(*3*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection on permissible dose for internal radiation, Report No. 2. Pergamon Press, New York, N.Y. (1959).

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Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide, however, an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5, 6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to assess man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in Milk, HASL	July–December 1965	June 1966
United Kingdom Milk	1962–1965	June 1966

1. Pasteurized Milk Network
April 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1), provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedure employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).

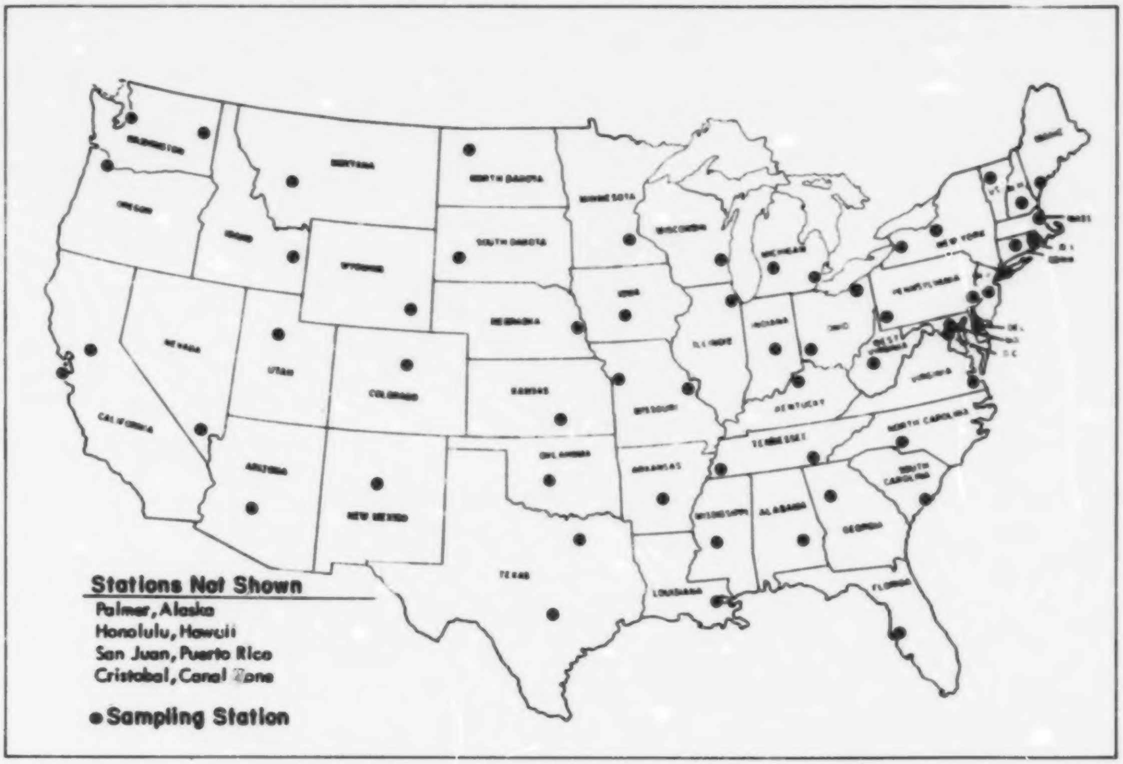

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average radionuclides concentration in pasteurized milk for the first quarter and April 1966 [a]

Sampling locations		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		First quarter 1966	April 1966	First quarter 1966	April 1966
Ala:	Montgomery	12	12	25	25
Alaska:	Palmer	14	14	40	35
Ariz:	Phoenix	4	3	15	15
Ark:	Little Rock	26	28	40	35
Calif:	Sacramento	6	12	15	20
	San Francisco	7	11	20	20
C.Z:	Cristobal	4	3	25	25
Colo:	Denver	11	12	25	25
Conn:	Hartford	11	12	40	40
Del:	Wilmington	13	17	40	40
D.C:	Washington	12	12	30	30
Fla:	Tampa	11	9	105	120
Ga:	Atlanta	19	19	40	35
Hawaii:	Honolulu	5	6	35	30
Idaho:	Idaho Falls	13	14	40	40
Ill:	Chicago	11	13	35	45
Ind:	Indianapolis	12	13	30	30
Iowa:	Des Moines	14	12	30	30
Kans:	Wichita	13	14	20	20
Ky:	Louisville	16	16	25	20
La:	New Orleans	29	30	40	45
Maine:	Portland	15	18	65	70
Md:	Baltimore	13	13	30	25
Mass:	Boston	14	15	60	60
Mich:	Detroit	11	12	35	40
	Grand Rapids	14	13	45	45
Minn:	Minneapolis	20	19	40	45
Miss:	Jackson	23	24	25	25
Mo:	Kansas City	15	13	20	30
	St. Louis	15	15	30	25
Mont:	Helena	15	15	60	65
Nebr:	Omaha	15	12	25	30
Nev:	Las Vegas	7	6	20	25
N.H:	Manchester	18	18	75	80
N.J:	Trenton	12	14	40	35
N. Mex:	Albuquerque	6	6	15	20
N.Y:	Buffalo	10	11	40	40
	New York	13	13	45	40
	Syracuse	10	13	40	40
N.C:	Charlotte	20	17	30	25
N. Dak:	Minot	31	32	45	45
Ohio:	Cincinnati	12	14	25	30
	Cleveland	13	13	35	40
Okla:	Oklahoma City	13	13	25	20
Ore:	Portland	12	14	35	40
Pa:	Philadelphia	12	14	35	35
	Pittsburgh	17	17	45	50
P.R:	San Juan	8	7	25	20
R.I:	Providence	12	14	45	45
S.C:	Charleston	23	19	45	40
S.Dak:	Rapid City	19	19	45	40
Tenn:	Chattanooga	21	20	25	35
	Memphis	17	17	15	15
Tex:	Austin	6	5	15	10
	Dallas	14	16	20	20
Utah:	Salt Lake City	13	12	40	40
Vt:	Burlington	14	15	55	55
Va:	Norfolk	16	14	25	30
Wash:	Seattle	15	15	40	50
	Spokane	15	15	40	45
W. Va:	Charleston	14	15	25	25
Wis:	Milwaukee	11	10	40	45
Wyo:	Laramie	14	10	30	25
Network average		13.8	14.2	35	36

[a] Calcium analyses were discontinued as of March 31, 1966; strontium-89 analyses were discontinued except for a minimum of 10 percent of selected samples; all analyses were <5 pCi/liter with the exception of a composite sample collected April 15 and April 22 at Omaha, Nebraska, which had a value of 15 pCi/liter. All iodine-131 and barium-140 values were below detectable levels.

The averages for April and the first quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values are below minimum detectable concentrations (*1*), averages are calculated using one-half the minimum detectable value.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for April 1965, and November 1965 through April 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2. During April 1966, the monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

Table 2. Frequency distribution, strontium-90 concentration in milk at PMN stations for April and November–December 1965 and January–April 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965			1966			
	Apr	Nov	Dec	Jan	Feb	Mar	Apr
Under 10	5	9	9	10	9	9	8
10–19	23	43	43	46	46	44	50
20–29	27	9	11	6	7	7	3
30–39	5	2	0	1	1	3	2
40–49	2	0	0	0	0	0	0
50–59	0	0	0	0	0	0	0
60–69	1	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at PMN stations for April and November–December 1965 and January–April 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965			1966			
	Apr	Nov	Dec	Jan	Feb	Mar	Apr
Under 50	7	57	51	57	56	56	55
50–99	35	5	11	5	6	6	7
100–149	18	1	1	1	1	1	1
150–199	3	0	0	0	0	0	0

75

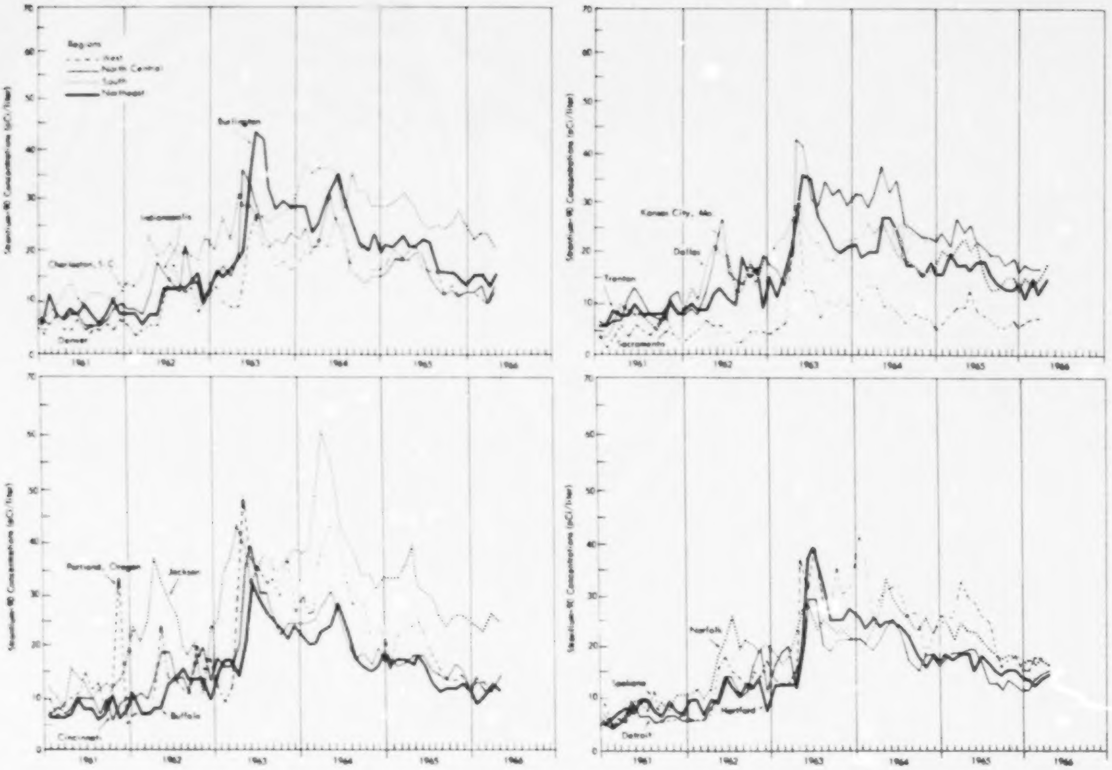

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–April 1966

2. Canadian Milk Network
April 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Canadian Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The April 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4.

Table 4. Stable elements and radionuclides in Canadian whole milk, April 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.4	19.2	73
Edmonton	1.11	1.5	16.9	61
Ft. William	1.04	1.5	24.6	48
Fredericton	1.13	1.5	28.0	79
Halifax	1.13	1.5	21.5	71
Montreal	1.10	1.6	15.5	50
Ottawa	1.15	1.6	12.0	43
Quebec	1.08	1.6	29.0	90
Regina	1.09	1.5	17.0	37
St. John's, Nfld.	1.10	1.6	24.8	67
Saskatoon	1.14	1.5	17.9	41
Sault Ste. Marie	1.04	1.6	22.1	75
Toronto	1.13	1.6	8.5	33
Vancouver	1.06	1.6	23.3	100
Windsor	1.12	1.5	6.7	37
Winnipeg	1.06	1.6	17.2	69
Average	1.10	1.5	19.0	61

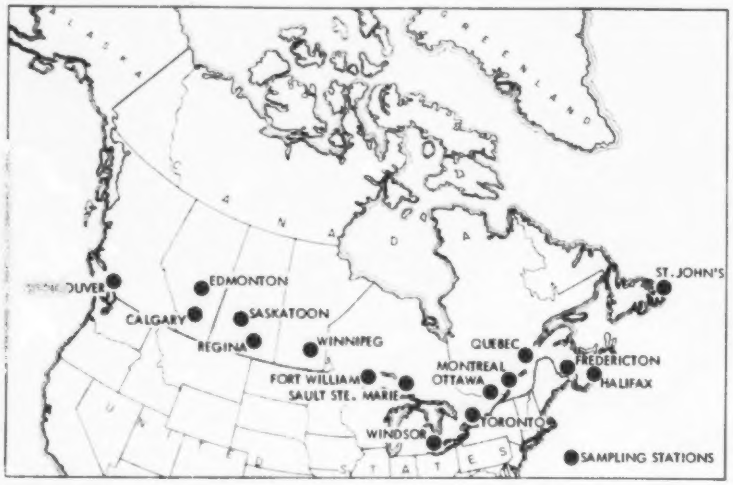
ALASKA
GREENLAND
CANADA
UNITED STATES
VANCOUVER
EDMONTON
CALGARY
SASKATOON
REGINA
WINNIPEG
FORT WILLIAM
SAULT STE. MARIE
QUEBEC
MONTREAL
OTTAWA
WINDSOR
TORONTO
ST. JOHN'S
FREDERICTON
HALIFAX
SAMPLING STATIONS

Figure 3. Canadian milk sampling stations

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[1] Prepared from May 1966 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program April 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

Table 5 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations.

Table 5. PAHO stable element and radionuclide concentrations in milk, April 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	NS	1.38	0	3	25
Jamaica:					
Kingston	1.20	1.39	<5	13	205
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	NS	1.5	0	7	20
Venezuela:					
Caracas	NS	NS	NS	NS	NS

NS, no sample collected.

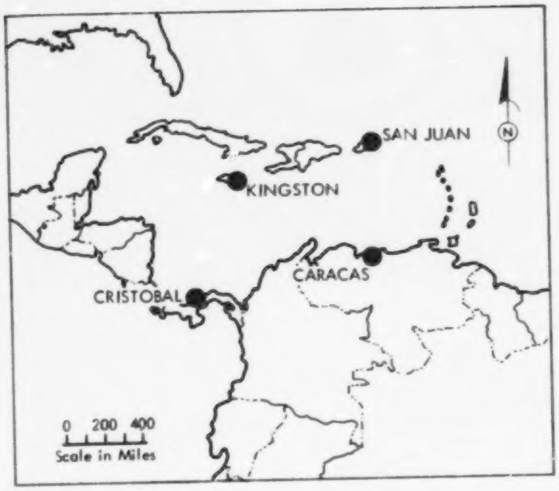

Figure 4. Pan American Milk Network sampling locations

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(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH and DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

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(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed toward the use of milk as an indication of dietary intake radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

Milk network	Period reported	Last presented
California	October–December 1965	June 1966
Colorado	October–December 1964	April 1965
Florida	January–March 1966	July 1966
New York	July–December 1965	May 1966
Oklahoma	January–March 1966	July 1966
Oregon	October–December 1965	June 1966
Texas	January–March 1966	July 1966
Washington	October–December 1965	June 1966

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1. Connecticut Milk Network
January–March 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma emitters are determined by gamma-scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

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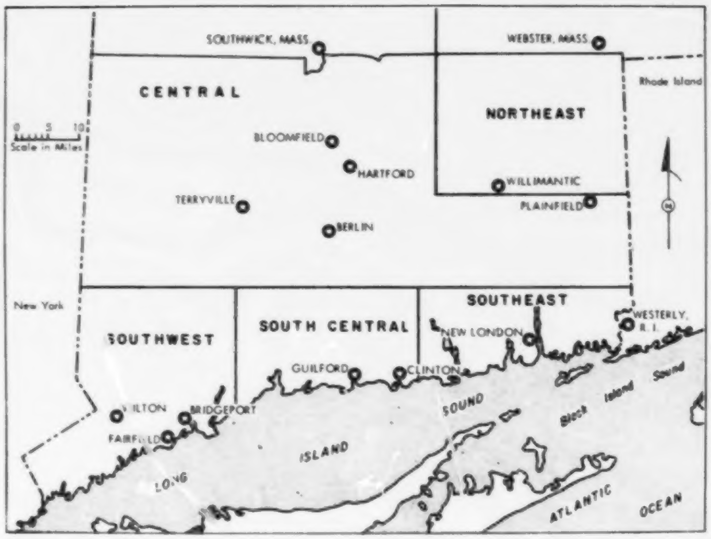
SOUTHWICK, MASS.
WEBSTER, MASS.
Rhode Island
CENTRAL
NORTHEAST
0 5 10
Scale in Miles
BLOOMFIELD
HARTFORD
WILLIMANTIC
PLAINFIELD
TERRYVILLE
BERLIN
New York
SOUTHEAST
WESTERLY, R.I.
SOUTHWEST
SOUTH CENTRAL
NEW LONDON
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
SOUND
Block Island Sound
ISLAND
LONG
ATLANTIC
OCEAN

Figure 1. Connecticut pasteurized milk sampling areas

Table 1. Radionuclide concentrations in central Connecticut milk, January–March 1966

Month	Concentration, pCi/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
January	<1	12	<10	40
February	<1	12	<10	30
March	<1	12	<10	40

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April 1960–December 1962	May 1963
Annual summary 1963	September 1964
Annual summary 1964	May 1965
Annual summary 1965	May 1966

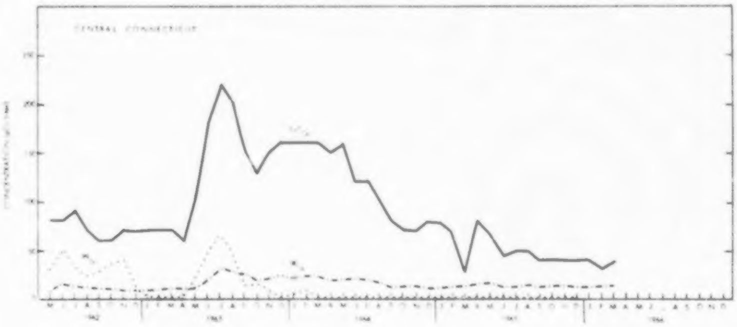

Figure 2. Radionuclide concentrations in Connecticut pasteurized milk

2. Indiana Milk Network
January-March 1966

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

Monthly analyses are performed for strontium-89, strontium-90, cesium-137, iodine-131, and barium-140, and for calcium and potassium-40. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency has been once a month for the northeast, southeast, and southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (*1,2*), while cesium-137, iodine-131, and barium-140 are determined by gamma-scintillation spectrometry (*3*).

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 2 for January through March 1966. During this period the monthly concentrations of strontium-89, iodine-131, and barium-140 remained below limits of detectability (*3*).

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 4.

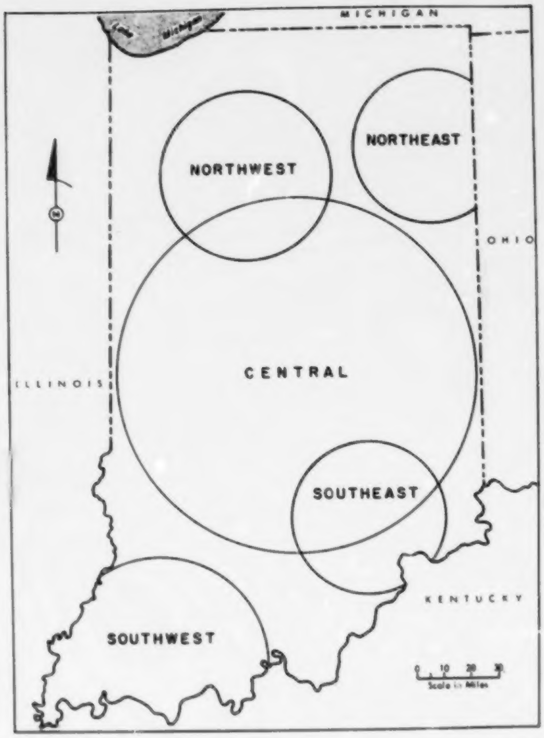

Figure 3. Indiana pasteurized milk sampling areas

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Summary 1961-1964	May 1965
Annual summary 1965	May 1966

Table 2. Radionuclides in Indiana milk, January-March 1966

Sampling locations	Calcium, g/liter			Potassium-40, pCi/liter			Strontium-90, pCi/liter			Cesium-137, pCi/liter		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Northeast	1.17	1.17	1.15	1,400	1,360	1,400	10	9	10	30	25	25
Southeast	1.17	1.17	1.21	1,340	1,590	1,460	15	14	15	25	40	30
Central	1.17	1.15	1.15	1,360	1,370	1,320	14	10	10	30	25	25
Southwest	1.15	1.19	1.15	1,360	1,390	1,350	12	11	13	25	25	20
Northwest	1.17	1.15	1.15	1,400	1,420	1,370	13	10	13	30	30	30
Average	1.17	1.17	1.16	1,370	1,430	1,380	13	11	12	30	30	25

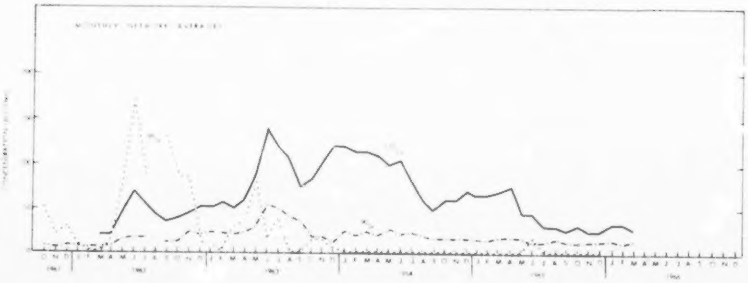

Figure 4. Radionuclide concentrations in Indiana pasteurized milk

3. Minnesota Milk Network January–March 1966

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium–90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 5) and analyzed for strontium–90, iodine–131, and cesium–137. One-liter samples of processed Grade-A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health District offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Strontium–90 concentrations are determined radiochemically, while iodine–131 and cesium–137 concentrations are determined by gamma-scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (*4*).

Strontium–90 (table 3), iodine–131 (table 4), and cesium–137 (table 3), concentrations in milk are given for January through March 1966. The strontium–90, cesium–137, and iodine–131 concentrations in Minnesota pasteurized milk are presented graphically by milkshed in figure 6 for the period 1962–March 1966.

Table 3. Radionuclide concentrations in Minnesota milk January–March 1966

Sampling location	Month	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Bemidji	January	29	80
	February	31	81
	March	25	80
Mankato	January	12	32
	February	11	57
	March	11	52
Rochester	January	14	33
	February	14	48
	March	13	36
Duluth	January	26	58
	February	24	62
	March	37	143
Worthington	January	14	32
	February	14	41
	March	7	40
Minneapolis	January	24	64
	February	15	21
	March	17	60
Fergus Falls	January	17	50
	February	16	55
	March	15	52
Little Falls	January	20	53
	February	18	62
	March	19	59
Average	January	19	50
	February	18	53
	March	18	65

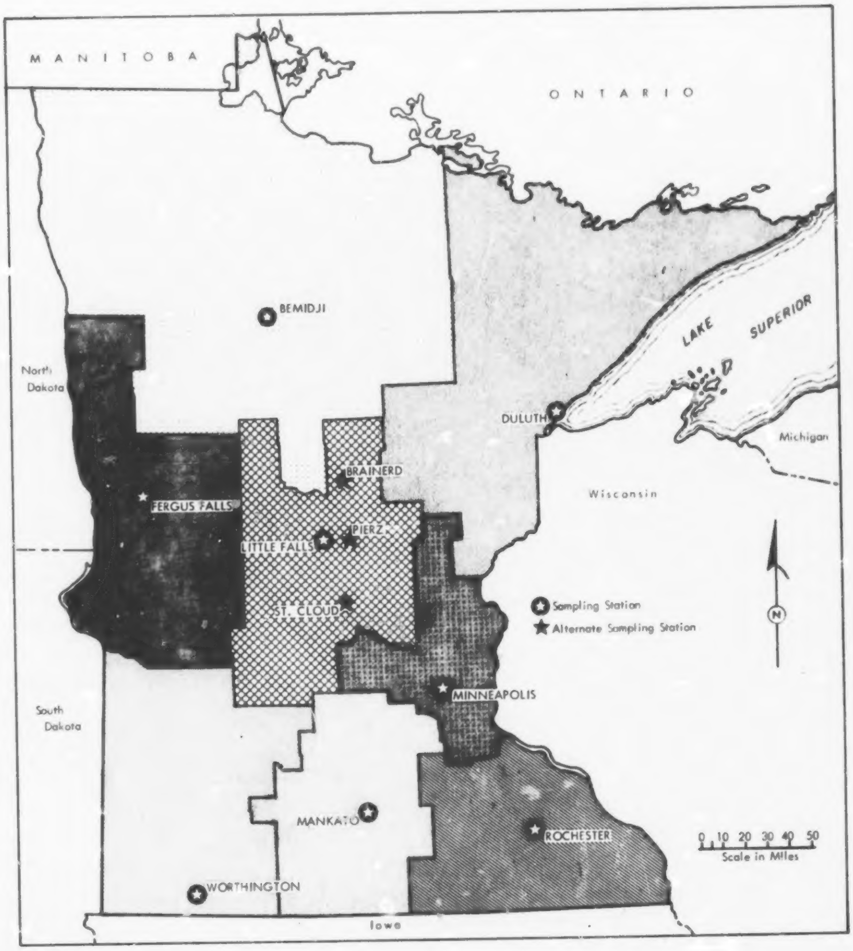
MANITOBA
ONTARIO
BEMIDJI
LAKE SUPERIOR
North Dakota
DULUTH
Michigan
BRAINERD
Wisconsin
FERGUS FALLS
PIERZ
LITTLE FALLS
Sampling Station
Alternate Sampling Station
ST. CLOUD
N
MINNEAPOLIS
South Dakota
MANKATO
ROCHESTER
0 10 20 30 40 50
Scale in Miles
WORTHINGTON
Iowa

Figure 5. Minnesota milk sampling locations

Table 4. Iodine-131 concentrations in Minnesota milk January–March 1966

Collection point	Collection date 1966	Iodine-131 (pCi/liter)
Bemidji	February 8 March 7	11 10
Little Falls	March 7	12
Worthington	March 7	16

Note: The results given are single values. The remaining 20 samples collected from the Minnesota Health Districts during the period January through March 1966 contained less than 10 picocuries iodine-131 per liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1964	July 1965
January–June 1965	January 1966
July–December and annual summary 1965	May 1966

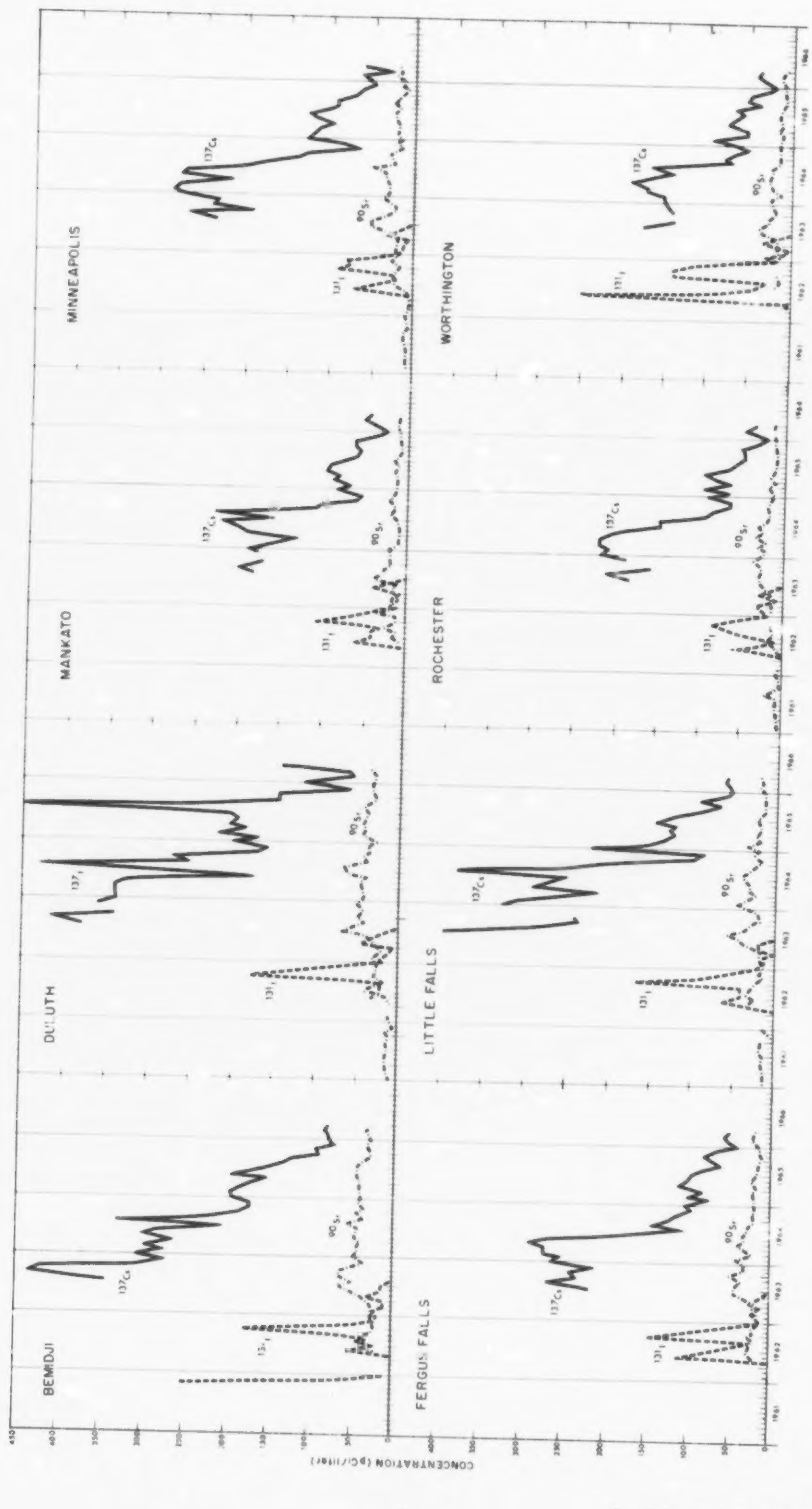

Figure 6. Radionuclide concentrations in Minnesota milk, 1962–March 1966

4. Pennsylvania Milk Network
January–March 1966

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 7). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location, subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter and Kahn (*2*).

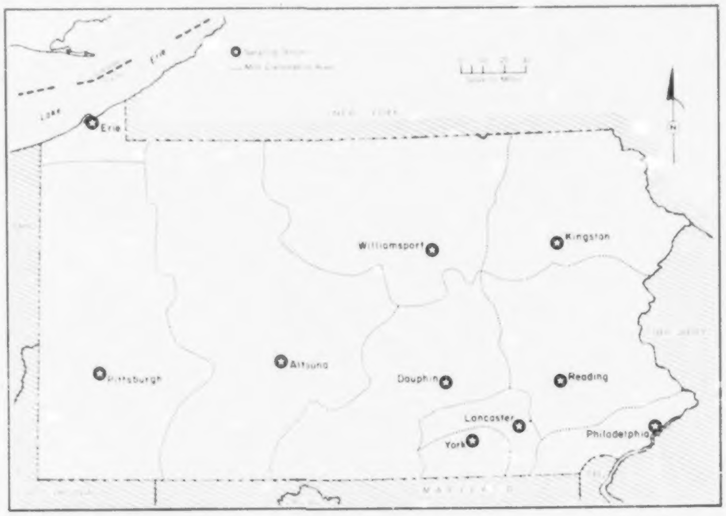

Figure 7. Pennsylvania pasteurized milk network sampling locations

Table 5. Potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in Pennsylvania milk, January–March 1966

Sampling location	Potassium-40, pCi/liter			Strontium-90, pCi/liter			Iodine-131, pCi/liter			Cesium-137, pCi/liter		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Altoona	1,063	874	915	15	20	19	<10	<10	<10	64	22	37
Dauphin	1,043	851	930	13	16	18	<10	<10	<10	60	31	30
Erie	1,066	863	980	23	20	22	<10	<10	<10	71	45	43
Kingston	1,047	832	952	19	21	17	<10	<10	<10	61	32	33
Lancaster	1,008	813	980	12	15	15	<10	<10	<10	61	27	31
Philadelphia	1,050	877	860	20	16	15	<10	<10	<10	61	24	24
Pittsburgh	1,055	806	785	19	23	20	<10	<10	<10	69	33	29
Reading	1,088	1,010	916	13	14	12	<10	<10	<10	69	35	24
Williamsport	970	876	842	22	18	18	<10	<10	<10	59	23	24
York	1,067	909	940	18	13	14	<10	<10	40	68	24	32
Average	1,046	871	910	17	18	17	<10	<10	<10	64	30	31

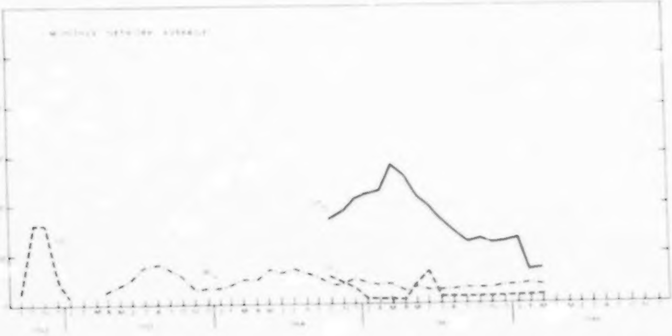

Figure 8. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962–March 1966

The monthly average potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in pasteurized milk are given in table 5. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 8.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
August–September 1964	February 1965
Annual summary 1964	June 1965
Annual summary 1965	May 1966

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(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) PORTER, C., and B. KAHN. Improved determinations of strontium-90 in milk by an ion-exchange method. Anal Chem 36:676–678 (March 1964).

(*3*) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION. Indiana Milk Network, April–June 1965. Rad Health Data 6:612–614 (November 1965).

(*4*) MINNESOTA DEPARTMENT OF HEALTH and RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January–June 1965, semiannual report, COO-615-17. Minnesota Department of Health, Minneapolis, Minnesota (August 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. The most recent coverage of programs not reported in this issue of *Radiological Health Data and Reports* is listed below:

Program	Period reported	Last presented
Institutional Total Diet	October–December 1965	July 1966
Tri-City Diet, *HASL*	Annual summary 1965	June 1966
California Diet	May–August 1965	June 1966
Connecticut Standard Diet	January–June 1965	February 1966

1. Radionuclides in Diets for Teenagers February–November 1965

Division of Pharmacology
Food and Drug Administration

It has been estimated that males in the 16- to 19-year-old age group ingest more food daily than individuals in any other segment of the U.S. population (*1*). Therefore, the Food and Drug Administration (FDA) chose this segment for a test of the maximum radionuclide intake of all population groups. As recommended by the U.S. Department of Agriculture, (USDA) the food plan used for this test consisted of a nutritionally adequate diet at a moderate cost level for boys 16 to 19 years of age (*2*). For the purposes of the sampling program, amounts of foods selected from the 11 food groups of the USDA plan were proportioned according to the 1965 Household Food Consumption Survey (*3*).

The FDA study of radionuclides in diets for teenagers was begun on a pilot basis in May 1961 in the Washington, D.C., area. Since then, the program has expanded to include eight other cities—San Francisco, Minneapolis, St. Louis, Atlanta, Denver, Boston, Dallas, and Seattle.

Sampling and analytical procedures

To duplicate the diet of a 19-year-old male, a list of 82 different items of food and drink was prepared. Quarterly samples of these items, covering a 2-week consumption period, were purchased from national food chain stores. Efforts were made to locate the sources of the food items and to arrange representation in the samples on the broadest possible geographical basis.

The foods were prepared by professional dietitians in diet kitchens at each city in a manner comparable to domestic preparation procedures. The most acceptable home practices for washing, trimming, bone removal, and separation of wastes and cooking water were used. Representative portions of the foods (including about 8 liters of drinking water) were homogenized into a slurry, and aliquots were analyzed for strontium–90 and cesium–137 at the nearest FDA District laboratory. Strontium–90 was separated radiochemically and its concentration determined by beta-counting, while gamma spectrometry was employed for cesium–137 analysis (*4,5*).

Results

Concentrations and daily intakes of strontium–90 and cesium–137, based on the quarterly samples for February to November 1965 are presented in tables 1 and 2. Individual station values for the quarter ending in the month shown are given along with the network averages for samples from nine cities. Denver, Colorado, generally had the highest daily strontium–90 intakes for the 1965 period, while San Francisco, California, had the lowest daily strontium–90 intake values. Minneapolis, Minnesota, had the highest daily cesium–137 intake for the 1965 period, while Dallas, Texas, had the lowest daily cesium–137 intake values.

Strontium–90

The network average daily strontium–90 intakes through November 1965 are presented in figure 1 and the range of values for the stations represented is indicated. Prior to May 1962, only one location, Washington, D.C., was sampled. The average strontium–90 intake in the diet is seen to have increased steadily from 14 pCi/day in May 1961 to 53 pCi/day in February 1964, after which it has been relatively constant, varying between 41 and 56 pCi/day, representing about one-quarter of the top of Range II (200 pCi/day) as recommended by the Federal Radiation Council (*6*).

Cesium–137

The cesium–137 average daily intakes and ranges through November 1965 are presented graphically in figure 2. The general trend of cesium–137 intakes for 1965 is downward. The peak average value, 366 pCi/day, was observed in May 1963.

Table 1. Strontium-90 concentrations and intakes in the total diet, quarterly samples, February–November 1965

Sampling locations		February		May		August		November	
		pCi/kg	pCi/day [a]	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Calif:	San Francisco	6	22	6	22	5	19	4	15
Colo:	Denver	9	34	17	64	19	71	24	90
D.C:	Washington	11	41	13	50	11	41	8	30
Ga:	Atlanta	NA	NA	17	64	12	45	12	45
Mass:	Boston	NA	NA	NA	NA	11	41	12	45
Minn:	Minneapolis	14	53	16	60	14	53	17	64
Mo:	St. Louis	NA	NA	12	45	12	45	NA	NA
Tex:	Dallas	8	30	11	41	8	30	8	30
Wash:	Seattle	11	41	17	64	8	30	9	34
Average		10	38	15	56	11	41	12	45

[a] Intakes based on the consumption of 3.76 kg food and drink for the 16- to 19-year-old male.
NA, no analysis performed

Table 2. Cesium-137 concentrations and intakes in the total diet, quarterly samples, February–November 1965

Sampling locations		February		May		August		November	
		pCi/kg	pCi/day [a]	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Calif:	San Francisco	39	147	NA	NA	33	124	22	83
Colo:	Denver	33	124	40	150	39	147	26	98
D.C:	Washington	49	184	55	207	35	132	24	90
Ga:	Atlanta	52	196	47	177	38	143	36	135
Mass:	Boston	50	188	64	241	51	192	41	154
Minn:	Minneapolis	63	237	66	248	56	211	42	158
Mo:	St. Louis	35	132	28	105	NA	NA	NA	NA
Tex:	Dallas	30	113	26	98	19	71	21	79
Wash:	Seattle	48	180	NA	NA	54	203	37	139
Average		44	165	47	177	41	154	31	117

[a] Intakes based on the consumption of 3.76 kg food and drink for the 16- to 19-year-old male.
NA, no analysis performed

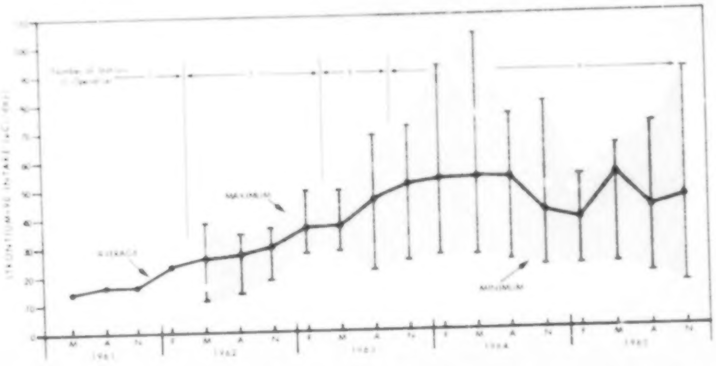

Figure 1. Averages and ranges of daily strontium-90 intake in FDA teenage standard diet

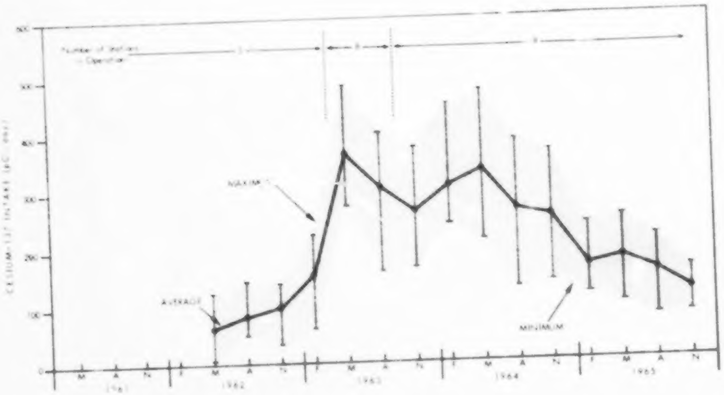

Figure 2. Averages and ranges of daily cesium-137 intake in FDA teenage standard diet

REFERENCES

(1) THE NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL. Recommended dietary allowances, National Research Council Pub 589, Revised. 2101 Constitution Avenue, Washington, D.C. 20418 (1958).

(2) U.S. DEPARTMENT OF AGRICULTURE. Family food plans and food costs. Home Economics Research Report No. 20. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (November 1962).

(3) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1956).

(4) LAUG, E. P., A. MIKALIS, H. M. BOLLINGER, and J. M. DIMITROFF. Total diet study: A. Strontium-90 and cesium-137 content. JAOAC 46:4 (1963).

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Previous coverage in *Radiological Health Data:*

Period	Issue
May 1961–August 1962	January 1963
May 1962–February 1963	June 1963
May 1963–November 1963	April 1964
February–November 1964	July 1965

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guidelines recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, *HASL*	May and July–November 1965	June 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
California Water Sampling Program	January–June 1965	March 1966
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. PHS Pub No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, FEBRUARY 1966

Basic Data Program
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The figures for gross alpha and beta radioactivity represent either determination on composites or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as < 1 pCi/liter. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-

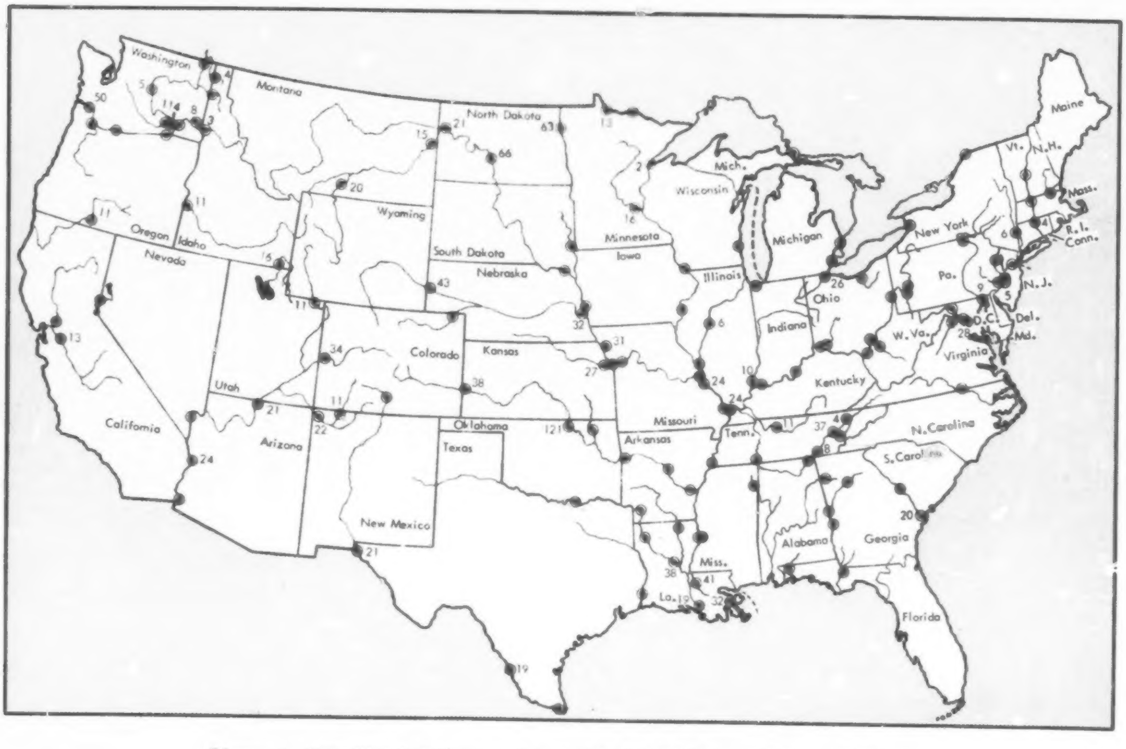
Washington
50
5
114
8
3
Montana
North Dakota
21
15
63
13
66
20
Wyoming
11
11
Oregon
Idaho
Nevada
16
South Dakota
Nebraska
43
11
Minnesota
Iowa
2
Mich.
Wisconsin
16
Michigan
Illinois
6
26
Ohio
Indiana
New York
Pa.
6
4
9
5
N.J.
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
D.C.
Del.
Md.
W. Va.
28
Virginia
13
California
34
Colorado
Kansas
32
31
27
38
Utah
21
11
22
Arizona
24
Oklahoma
121
Texas
New Mexico
21
Missouri
Arkansas
24
24
10
Kentucky
Tenn.
11
37
4
8
N. Carolina
S. Carolina
20
Georgia
Alabama
Miss.
38
41
La.
19
32
Florida
19

Figure 1. Sampling locations and associated total beta activity, pCi/liter, in surface waters, February 1966

dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

Table 1. Radioactivity in raw surface waters, February 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	1	10	11	<1	2	2
Arkansas River:						
Coolidge, Kans	7	31	38	1	15	16
Ponca City, Okla	17	104	121	3	23	26
Atchafalaya River:						
Morgan City, La	7	12	19	3	1	4
Bear River:						
Preston, Idaho	1	15	16	0	2	2
Big Horn River:						
Hardin, Mont	2	18	20	0	6	6
Chena River:						
Fairbanks, Alaska	1	4	5	0	0	0
Clearwater River:						
Lewiston, Idaho	<1	3	3	0	1	1
Clinch River:						
Clinton, Tenn	0	4	4	0	0	0
Kingston, Tenn[a]	2	35	37	0	<1	<1
Colorado River:						
Loma, Colo	9	25	34	1	8	9
Page, Ariz	<1	21	21	0	5	5
Parker Dam, Calif-Ariz	1	23	24	0	7	7
Columbia River:						
Wenatchee, Wash	0	5	5	0	1	1
Pasco, Wash[a]	28	86	114	0	2	2
Clatskanie, Ore	16	34	50	0	1	1
Connecticut River:						
Enfield Dam, Conn	0	4	4	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	6	5	11	2	0	2
Delaware River:						
Philadelphia, Pa	0	5	5	0	0	0
Great Lakes:						
Duluth, Minn	0	2	2	0	0	0
Green River:						
Dutch John, Utah	<1	11	11	0	1	1
Hudson River:						
Poughkeepsie, N.Y	0	6	6	0	0	0
Illinois River:						
Peoria, Ill	1	5	6	1	3	4
Kansas River:						
DeSoto, Kans	6	21	27	1	3	4
Klamath River:						
Keno, Ore	1	10	11	<1	0	<1
Maumee River:						
Toledo, Ohio	1	25	26	1	5	6
Mississippi River:						
St. Paul, Minn	0	16	16	0	0	0
E. St. Louis, Ill	13	11	24	3	1	4
New Roads, La	31	10	41	6	1	7
New Orleans, La	21	11	32	6	1	7
Missouri River:						
Williston, N. Dak	5	16	21	1	4	5
Bismarck, N. Dak	50	16	66	13	3	16
St. Joseph, Mo	22	9	31	5	1	6
North Platte River:						
Henry, Nebr	2	41	43	1	25	26
Ohio River:						
Cairo, Ill	19	5	24	7	0	7
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	4	4	0	<1	<1
Platte River:						
Plattsmouth, Nebr	6	26	32	2	7	9
Potomac River:						
Washington, D.C	23	5	28	8	0	8
Rainy River:						
Baudette, Minn	<1	13	13	0	0	0
Red River, North:						
Grand Forks, N. Dak	0	63	63	0	1	1
Red River, South:						
Alexandria, La	24	14	38	9	1	10
Rio Grande:						
El Paso, Tex	4	17	21	0	6	6
Laredo, Tex	3	16	19	1	5	6
San Joaquin River:						
Vernalis, Calif	3	10	13	1	2	3
San Juan River:						
Shiprock, N. Mex	9	13	22	3	3	6
Savannah River:						
Port Wentworth, Ga[a]	5	15	20	<1	0	<1
Snake River:						
Payette, Idaho	1	10	11	0	3	3
Wawawai, Wash	0	8	8	0	3	3
Susquehanna River:						
Conowingo, Md	3	6	9	1	0	1
Tennessee River:						
Chattanooga, Tenn	1	7	8	0	0	0
Wabash River:						
New Harmony, Ind	2	8	10	0	1	1
Yellowstone River:						
Sidney, Mont	1	14	15	0	4	4
Maximum	50	104	121	13	25	26
Minimum	0	2	2	0	0	0

[a] Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

During January and February, the following stations showed alpha values slightly in excess of 15 pCi/liter in the dissolved solids:

North Platte River: Henry, Nebraska
Arkansas River: Coolidge, Kansas

Ponca City, on the Arkansas River, showed an increase of alpha radioactivity on dissolved solids to slightly more than 15 pCi/liter since January.

Kingston, Tennessee, on the Clinch River, and Pasco, Washington, on the Columbia River, showed a decrease in February to beta values of less than 150 pCi/liter.

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(2) Ibid., 1959 Edition.
(3) Ibid., 1960 Edition.
(4) Ibid., 1961 Edition.
(5) Ibid., 1962 Edition.
(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Pub No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity arising through air intrusions such as weapons testing fallout. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commision of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last reported
National Air Sampling Network	January–March 1966	July 1966
HASL Fallout Network	January–June 1965	May 1966

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1. Radiation Surveillance Network April 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified.

Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and analytical procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during April 1966. Time profiles of gross beta activity in air dating back to 1958 eight RSN stations are shown in figure 2.

Network samples for the month of April included several in which fresh fission products were identified as tabulated below.

The fresh fission products were identified with gamma scans; however, no results on individual radionuclides were derived. A possible explanation for the observed activities would be the Nevada Test Site (NTS) test of April 25, 1966, following which measurable amounts of radioactivity were observed northeast of the NTS (3).

Date April 1966	Location	Gross beta activity (pCi/m^3)
26	Salt Lake City, Utah	1.44
27	Denver, Colorado	0.93
	Salt Lake City, Utah	0.79
	Cheyenne, Wyoming	19.02
	Las Vegas, Nevada	0.53
28	Santa Fe, New Mexico	0.28
29	Las Vegas, Nevada	0.76

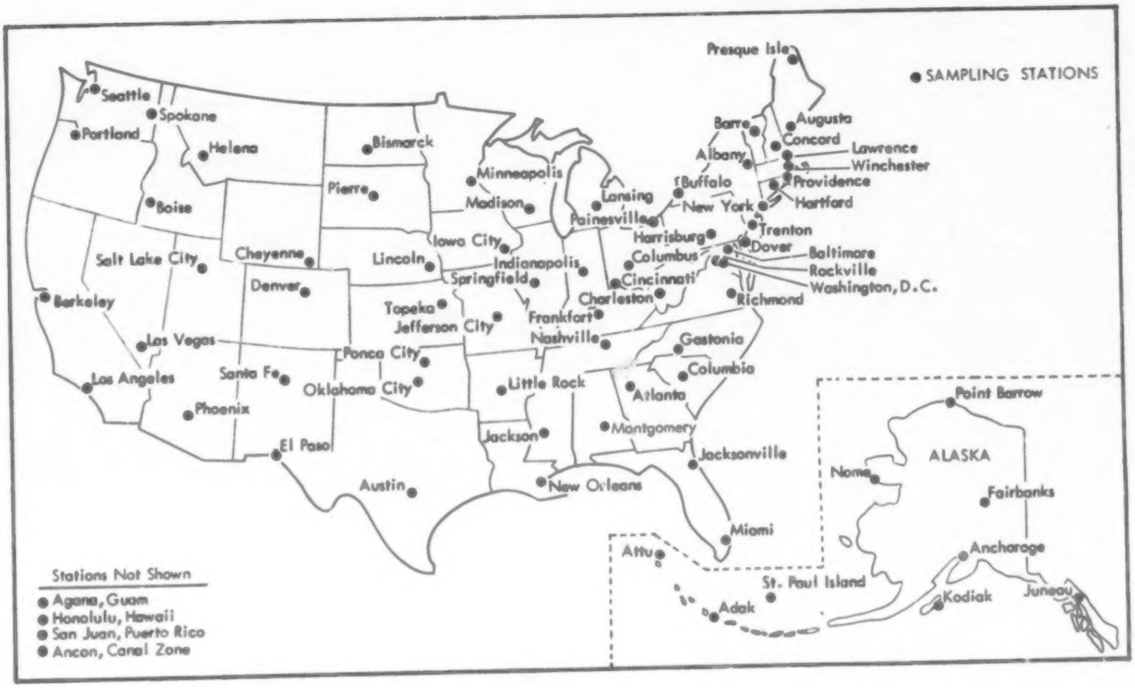
● SAMPLING STATIONS
Presque Isle
Seattle
Spokane
Portland
Helena
Bismarck
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Minneapolis
Buffalo
Providence
Pierre
Madison
Lansing
New York
Hartford
Boise
Painesville
Trenton
Iowa City
Harrisburg
Dover
Salt Lake City
Cheyenne
Lincoln
Indianapolis
Columbus
Baltimore
Rockville
Springfield
Cincinnati
Washington, D.C.
Denver
Charleston
Berkeley
Topeka
Richmond
Jefferson City
Frankfort
Las Vegas
Nashville
Gastonia
Ponca City
Columbia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Atlanta
Phoenix
Point Barrow
Montgomery
Jackson
El Paso
Jacksonville
ALASKA
Nome
Austin
New Orleans
Fairbanks
Miami
Anchorage
Attu
St. Paul Island
Juneau
Adak
Kodiak
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, April 1966

Station location		Number of samples		Air surveillance Gross beta activity, pCi/m³			Precipitation		
		Air	Pptn	Maximum	Minimum	Average [a]	Last profile in *RHD&R*	Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	2	0.27	<0.10	<0.14	Feb 66	32	<6
Alaska:	Adak	30		0.17	<0.10	<0.11	Jun 66	(c)	
	Anchorage	16	2	0.26	<0.10	<0.15	Mar 66	3	<1
	Attu Island	(b)					Jul 66	(c)	
	Fairbanks	(b)					Apr 66	(c)	
	Juneau	21	10	0.17	<0.10	<0.11	May 66	139	<28
	Kodiak	(b)					May 66	(c)	
	Nome	(b)					Dec 65	(c)	
	Pt. Barrow	27		0.12	<0.10	<0.10	Aug 66	(c)	
	St. Paul Island	30		<0.10	<0.10	<0.10	Jan 66	(c)	
Ariz:	Phoenix	28		0.50	0.12	0.20	May 66	(c)	
Ark:	Little Rock	23	7	0.17	<0.10	<0.11	Mar 66	182	<37
Calif:	Berkeley	21	2	0.29	<0.10	<0.16	May 66	18	<4
	Los Angeles	21		0.27	<0.10	<0.13	Dec 65	(c)	
C.Z.:	Ancon	16		<0.10	<0.10	<0.10	May 66	(c)	
Colo:	Denver	29	5	0.93	<0.10	<0.16	May 66	23	<5
Conn:	Hartford	28	9	0.17	<0.10	<0.11	Apr 66	27	<5
Del:	Dover	19		0.13	<0.10	<0.10	Feb 66	(c)	
D.C.:	Washington	29	7	0.14	<0.10	<0.10	Aug 66	79	<16
Fla:	Jacksonville	29	7	0.22	<0.10	<0.12	Mar 66	37	<8
	Miami	26	4	0.21	<0.10	<0.12	Apr 66	15	<3
Ga:	Atlanta	1	5	0.11	0.11	0.11	Jan 66	88	<18
Guam:	Agana	29		<0.10	<0.10	<0.10	Feb 66	(c)	
Hawaii:	Honolulu	29	1	0.18	<0.10	<0.11	Jul 66	8	<2
Idaho:	Boise	28	3	0.19	<0.10	<0.12	Jul 66	27	<5
Ill:	Springfield	29	6	0.14	<0.10	<0.10	Aug 66	163	<33
Ind:	Indianapolis	28	10	0.16	<0.10	<0.11	Jan 66	80	<16
Iowa:	Iowa City	30	7	0.12	<0.10	<0.10	May 66	81	<16
Kans:	Topeka	29	5	0.31	<0.10	<0.12	Mar 66	48	<10
Ky:	Frankfort	25	9	0.17	<0.10	<0.11	Aug 66	61	<12
La:	New Orleans	28	9	0.22	<0.10	<0.11	Aug 66	126	<25
Maine:	Augusta	30	9	0.19	<0.10	<0.11	Dec 65	31	<6
	Presque Isle	22		0.14	<0.10	<0.10	May 66	(c)	
Md:	Baltimore	20	5	0.14	<0.10	<0.10	Apr 66	50	<10
	Rockville	16		0.12	<0.10	<0.10	Jul 66	(c)	
Mass:	Lawrence	30	8	0.16	<0.10	<0.11	Feb 66	29	<6
	Winchester	28	7	0.17	<0.10	<0.10	Jun 66	25	<5
Mich:	Lansing	29	12	0.13	<0.10	<0.10	Jul 66	75	<15
Minn:	Minneapolis	20	6	0.12	<0.10	<0.10	Feb 66	24	<5
Miss:	Jackson	24	6	0.15	<0.10	<0.11	Dec 65	157	<32
Mo:	Jefferson City	30	11	0.20	<0.10	<0.11	Jan 66	142	<28
Mont:	Helena	30	7	0.26	<0.10	<0.13	Jun 66	20	<4
Nebr:	Lincoln	18	2	0.24	<0.10	<0.12	Jan 66	10	<2
Nev:	Las Vegas	26		0.76	<0.10	0.26	Apr 66	(c)	
N.H.:	Concord	18		0.22	<0.10	<0.12	Aug 66	(c)	
N.J.:	Trenton	30	4	0.19	<0.10	<0.11	Dec 65	8	<2
N. Mex:	Sante Fe	29	1	0.28	<0.10	<0.15	Jun 66	1	<1
N.Y.:	Albany	19	4	0.16	<0.10	<0.11	Jan 66	24	<5
	Buffalo	29		0.13	<0.10	<0.10	May 66	(c)	
	New York	28		0.15	<0.10	<0.10	Jun 66	(c)	
N.C.:	Gastonia	30	9	0.20	<0.10	<0.12	May 66	35	<7
N. Dak:	Bismarck	28	2	0.16	<0.10	<0.11	Aug 66	29	<6
Ohio:	Cincinnati	18		<0.10	<0.10	<0.10	Feb 66	(c)	
	Columbus	30	10	0.24	<0.10	<0.12	Dec 65	78	<16
	Painesville	30	8	0.18	<0.10	<0.11	Apr 66	69	<14
Okla:	Oklahoma City	29	9	0.13	<0.10	<0.10	Jul 66	80	<16
	Ponca City	27	5	<0.10	<0.10	<0.10	Apr 66	65	<13
Ore:	Portland	29	6	0.33	<0.10	<0.19	Jan 66	23	<5
Pa:	Harrisburg	29	3	0.13	<0.10	<0.10	Jan 66	49	<10
P.R.:	San Juan	29	3	0.16	<0.10	<0.11	Dec 65	111	<22
R.I.:	Providence	28	5	0.16	<0.10	<0.10	Jul 66	31	<6
S.C.:	Columbia	28	4	0.18	<0.10	<0.11	Jun 66	35	<7
S. Dak:	Pierre	29	2	0.17	<0.10	<0.11	May 66	11	<2
Tenn:	Nashville	29	11	0.14	<0.10	<0.10	Jul 66	105	<21
Tex:	Austin	29	5	0.14	<0.10	<0.11	Feb 66	91	<18
	El Paso	30	2	0.26	<0.10	<0.14	Aug 66	29	<6
Utah:	Salt Lake City	29	5	1.44	<0.10	<0.22	Dec 65	42	<9
Vt:	Barre	26	7	0.18	<0.10	<0.12	Mar 66	17	<3
Va:	Richmond	30	6	0.14	<0.10	<0.10	Mar 66	56	<11
Wash:	Seattle	30	8	0.12	<0.10	<0.10	Mar 66	43	<9
	Spokane	29	1	0.17	<0.10	<0.13	Feb 66	1	<1
W. Va:	Charleston	30	12	0.16	<0.10	<0.10	Jun 66	109	<22
Wis:	Madison	30	6	0.12	<0.10	<0.10	Mar 66	34	<7
Wyo:	Cheyenne	29	4	19.02	<0.10	<0.75	Apr 66	16	<3
Network summary		1,840	325	19.02	<0.10	<0.12		54	<11

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Indicates no report received.

[c] Indicates no precipitation sample collected.

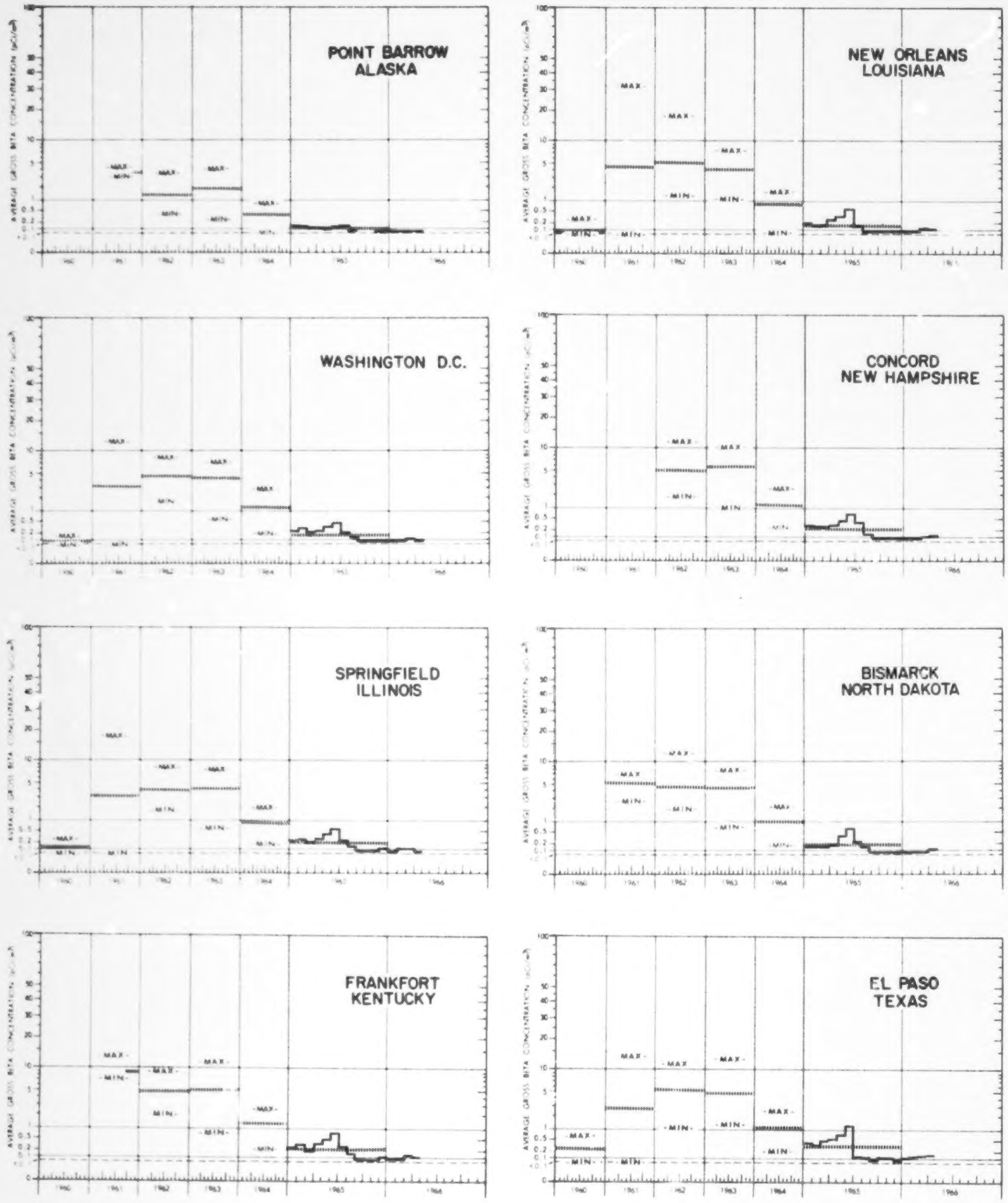

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960–April 1966

2. Canadian Air and Precipitation Monitoring Program April 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for April 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, April 1966

Station	Number of samples	Air surveillance (activity, pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.2	0.0	0.1	42	1.8
Coral Harbour	30	0.2	0.0	0.1	46	0.5
Edmonton	29	0.2	0.0	0.1	80	1.4
Ft. Churchill	28	0.2	0.0	0.1	70	1.9
Ft. William	29	0.2	0.0	0.1	53	1.7
Fredericton	28	0.2	0.0	0.1	95	1.5
Goose Bay	30	0.2	0.0	0.1	72	1.4
Halifax	30	0.2	0.0	0.1	80	1.9
Inuvik	30	0.2	0.0	0.1	126	0.8
Montreal	29	0.2	0.0	0.1	95	2.0
Moosonee	30	0.2	0.0	0.1	29	1.2
Ottawa	30	0.2	0.0	0.1	47	1.1
Quebec	30	0.2	0.0	0.1	121	2.2
Regina	30	0.3	0.0	0.1	28	1.1
Resolute	30	0.1	0.0	0.1	NS	NS
St. John's, Nfld	30	0.2	0.0	0.1	48	2.5
Saskatoon	30	0.2	0.0	0.1	75	1.3
Sault Ste. Marie	29	0.2	0.0	0.1	47	2.0
Toronto	30	0.2	0.0	0.1	75	2.5
Vancouver	30	0.2	0.0	0.1	79	2.0
Whitehorse	30	0.3	0.0	0.1	56	0.7
Windsor	28	0.2	0.0	0.1	28	2.5
Winnipeg	30	0.2	0.0	0.1	38	1.8
Yellowknife	30	0.2	0.0	0.1	37	0.8
Network summary		0.2	0.0	0.1	64	1.6

NS, no sample reported.

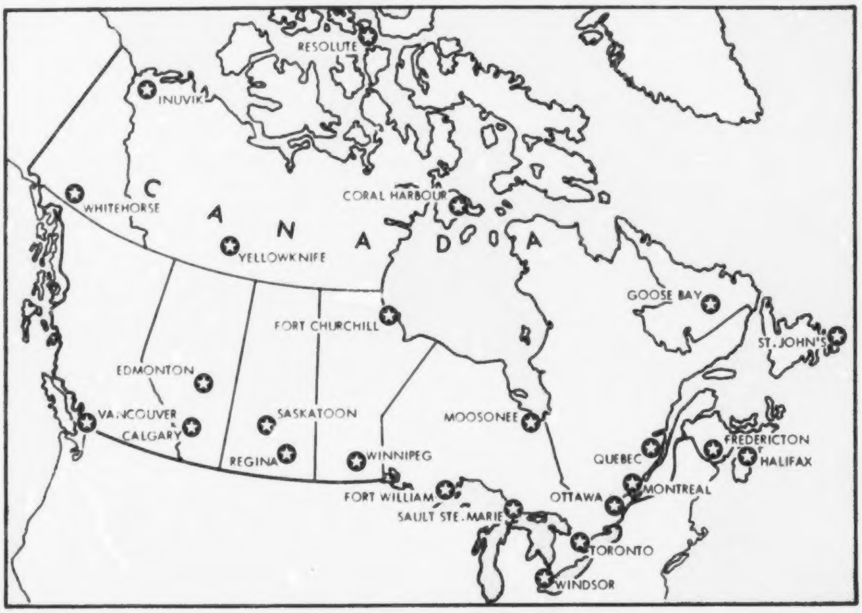
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the May 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program December 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961, the CNEN appointed its Division of Radiological Security (DRS) to establish a new radiation surveillance network. This network consists of 17 stations (figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Details of sampling procedures were presented in the December 1965 issue of *Radiological Health Data*. Samples are counted a minimum of 3 or 4 days after collection to allow for decay of radon and thoron. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission product beta activity concentrations in surface air during December 1965 are presented in table 3.

Table 3. Mexican gross beta activity of airborne particulates, December 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	9	<0.1	<0.1	<0.1
Ciudad Juarez	15	0.4	<0.1	<0.1
Chihuahua	21	0.7	<0.1	0.1
Ensenada	11	0.2	<0.1	<0.1
Guadalajara	16	0.5	<0.1	0.2
Guaymas	13	0.2	<0.1	<0.1
La Paz	22	0.1	<0.1	<0.1
Matamoros	NS			
Mazatlán	20	0.1	<0.1	<0.1
Mérida	13	0.1	<0.1	<0.1
Mexico, D.F.	17	0.2	<0.1	<0.1
Nuevo Laredo	8	0.1	<0.1	<0.1
San Luis Potosí	16	0.1	<0.1	<0.1
Tampico	16	0.1	<0.1	<0.1
Torreón	31	0.3	<0.1	<0.1
Tuxtla Gutierrez	NS			
Veracruz	16	0.1	<0.1	<0.1

NS, no sample collected—station temporarily shut down.

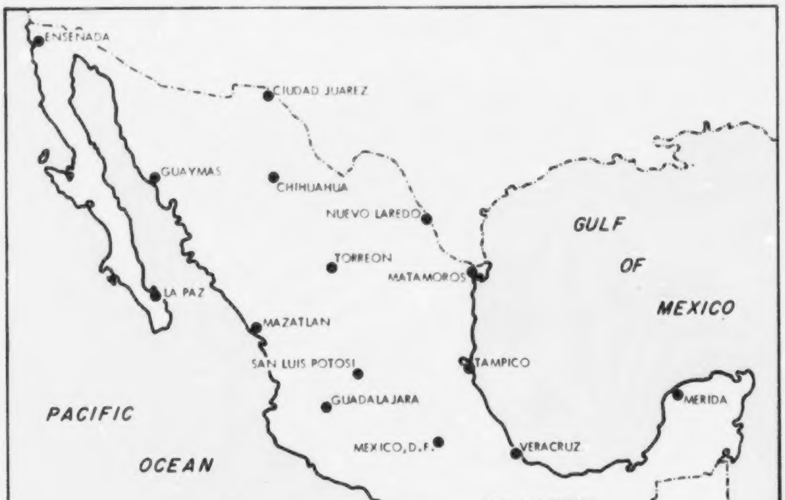

Figure 4. Fallout network sampling stations in Mexico

4. Pan American Air Sampling Program April 1966

Pan American Health Organization
and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assistant PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 5.

The April 1966 air monitoring results from the participating countries are given in table 4.

Table 4. PAHO gross beta activity in surface air, April 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	4	<0.10	<0.10	<0.10
Chile: Santiago	25	<0.10	<0.10	<0.10
Jamaica: Kingston	21	0.12	<0.10	<0.10
Peru: Lima	18	<0.10	<0.10	<0.10
Venezuela: Caracas	12	<0.10	<0.10	<0.10
West Indies: Trinidad	17	<0.10	<0.10	<0.10
Pan American summary	97	0.12	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.

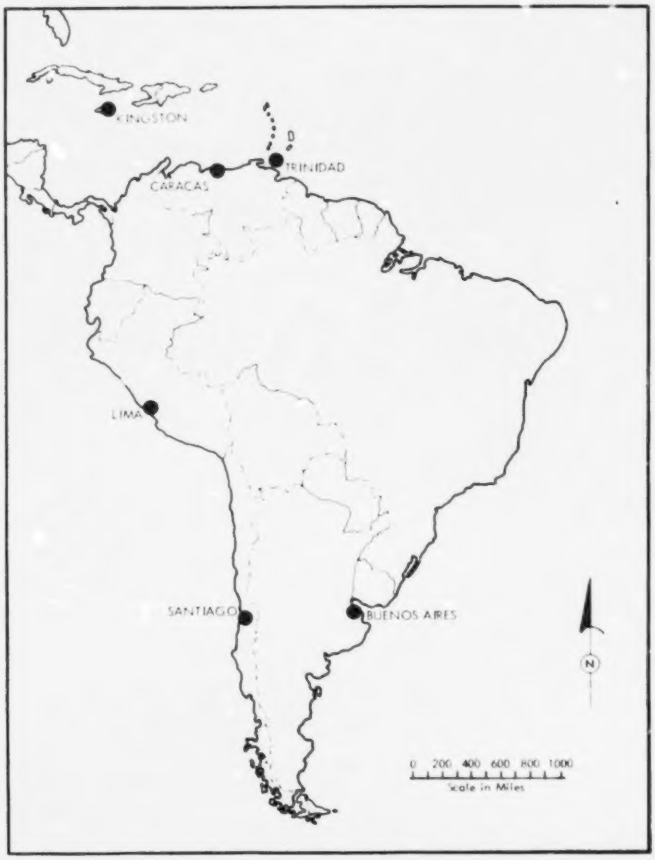

Figure 5. Pan American Air Network sampling stations

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(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH, RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Washington, D.C. 20201 (distribution by official request).

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(*4*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(*12*) ALBA, F., T. BRODY, and A. PALACIOS. Cuarto informe sobre estudios de la precipitación radiactiva. Revista Mericana de Fisica 8:60–85 (1959).

(*13*) BRODY, T. A., S. BULBULIAN, J. CALVILLO, and A. M. MARTINEZ. Quinto informe sobre estudios de precipitacion radiactiva. Revista Mexicana de Física 10:1–30 (1961).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of the environmental radioactivity data follow for the Pinellas Peninsula Plant and the Savannah River Plant.

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[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Pinellas Peninsula Plant July–December 1965[3]

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 1, is an electronic component production facility. The Plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Environmental monitoring includes sampling of a single combined sewer effluent, milk from three local dairy farms, and air and surface water obtained at locations suggested by meterological conditions and radioactivity discharge concentrations. Except for air samples, which may also contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack. Analysis of the one sample collected during the sampling period revealed no detectable amounts of tritium gas or tritium oxide. The limit of detection is 9,600,000 pCi/m^3 for tritium gas and 5,000 pCi/m^3 for tritium oxide.

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the Plant's property. During the sampling period, six of 110 samples analyzed showed detectable concentrations of tritium ($>$ 90,000 pCi/liter)[4]. The maximum concentration, 500,000 pCi/liter, was caused by radioactivity in the cooling water discharged from the Plant's incinerator during the burning of low level contaminated wastes. Calculations based on radioactivity releases from the process waste system, the incinerator, and the Plant's water discharges indicate that the average tritium concentration in the com-

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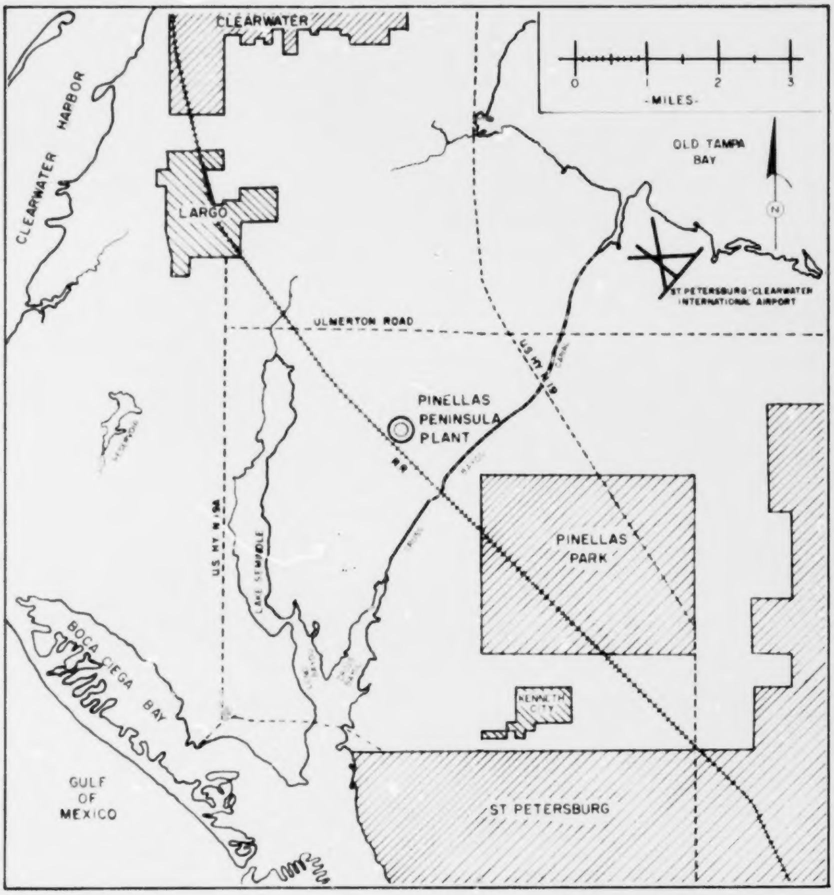
[3] Summarized from "Environmental Monitoring, July 1 through December 31, 1965," General Electric Company, Pinellas Peninsula Plant, St. Petersburg, Florida.

[4] Expressions in parentheses indicate limits of detectability in the respective environmental samples.


CLEARWATER
CLEARWATER HARBOR
0
1
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-MILES-
OLD TAMPA BAY
N
LARGO
ST PETERSBURG-CLEARWATER INTERNATIONAL AIRPORT
ULMERTON ROAD
US HY 19
PINELLAS PENINSULA PLANT
RR
US HY N 19A
LAKE SEMINOLE
PINELLAS PARK
BOCA CIEGA BAY
KENNETH CITY
GULF OF MEXICO
ST PETERSBURG

Figure 1. Location of the Pinellas Peninsula Plant

bined sewer effluent for the second half of 1965 was less than 0.8 percent of the AEC standard.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (> 90,000 pCi/liter) in the 46 surface water samples analyzed during the sampling period.

Milk sampling results

Fifteen samples of raw milk were collected from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1965. No detectable concentrations (> 90,000 pCi/liter) of tritium were evident.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1960–1961	July 1962
Calendar year 1962	June 1963
Calendar year 1963	September 1964
January–June 1964	February 1965
July–December 1964	August 1965
January–June 1965	February 1966

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2. Savannah River Plant July-December 1965[1]

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a fuel preparation area, four operating reactors, two fuel separation areas, and a heavy-water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to insure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (prior to plant start-up) to determine the concentrations of radioactive materials in a 1,200-square-mile area outside the plant. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) in the AEC Manual (see footnote 2).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Maxi-

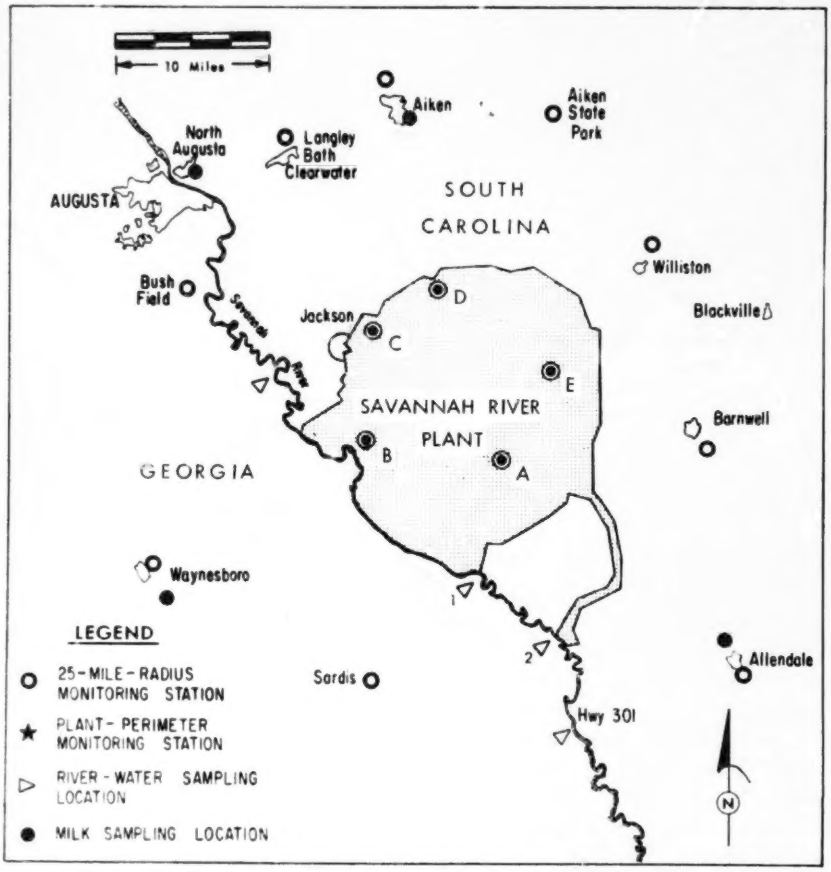
10 Miles
Aiken
Aiken State Park
North Augusta
Langley Bath Clearwater
AUGUSTA
SOUTH CAROLINA
Williston
Bush Field
Savannah River
Jackson
D
C
E
Blackville
SAVANNAH RIVER PLANT
B
A
Barnwell
GEORGIA
Waynesboro
1
2
Allendale
Sardis
Hwy 301
N
LEGEND
○ 25-MILE-RADIUS MONITORING STATION
★ PLANT-PERIMETER MONITORING STATION
▷ RIVER-WATER SAMPLING LOCATION
● MILK SAMPLING LOCATION

Figure 2. Environmental sampling locations, Savannah River Plant

mum and minimum values are given for individual samples collected during the reporting period.

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[1] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, July-December 1965" (DPST-66-30-1).

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations near the plant perimeter and nine stations around a circle of about a 25-mile radius from the center of the plant (figure 2). Deposition rates of radioactive materials in rainwater at each station were also determined by monthly analyses of ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant plant release of airborne activity would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from the plant that the effect of SRP operations is negligible; they are reference points for determining background activity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and plant releases.

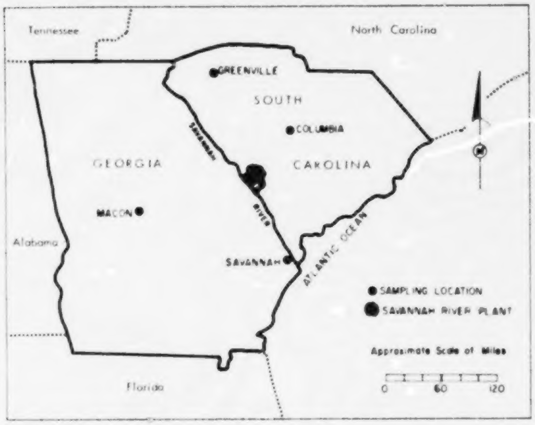

Figure 3. Distant air monitoring stations Savannah River Plant

The small amount of radioactive material released to the atmosphere, primarily from the fuel separations areas, was obscured by fallout from nuclear weapons tests. The influence of the weapons tests, which were resumed in September 1961, is shown in figure 4. Concentrations after July 1965 are only slightly above the lowest average ever observed at the plant (0.02 pCi/m³ in August 1961). The relative abundance of airborne radionuclides since January 1963 is shown in figure 5. The diminishing activity is proportional to the areas of the circles (and circle segments) which show average activity for each year. Fresh weapons tests fallout is indicated by the presence of ruthenium–103 and barium-lanthanum–140 during 1963 and 1964. Fallout from the Chinese nu-

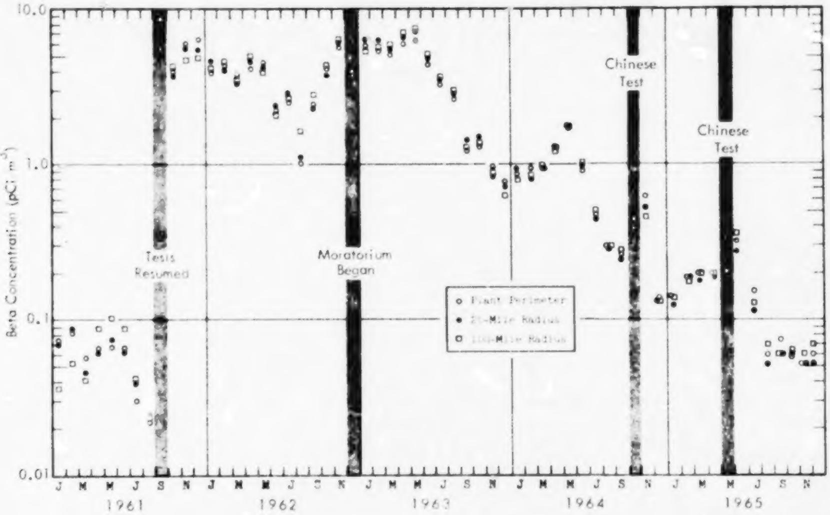

Figure 4. Influence of weapons tests

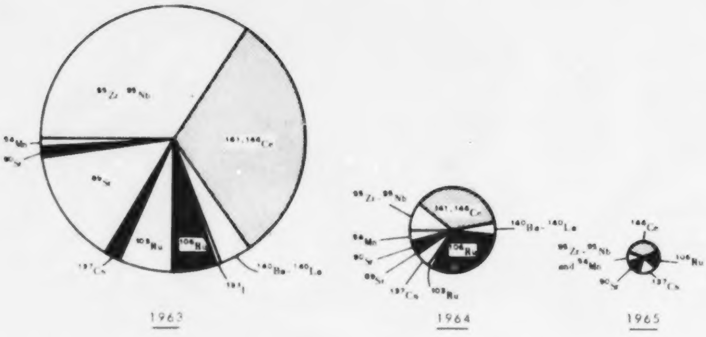

Figure 5. Relative abundance of airborne radionuclides (weapons test fallout)

clear detonation in May 1965 was low compared to the levels after the Chinese test in October 1964; the presence of short radioactive half-life barium-lanthanum-140 in high-volume air samples confirmed the presence of fresh fission products.

Radioactivity in air, determined from filter analyses, is shown in table 1. The July–December 1965 concentrations of filterable beta activity (0.07 pCi/m^3) and alpha activity (0.0007 pCi/m^3) in air were 0.07 percent and 1.8 percent of their respective MPC's. Tritium oxide concentrations in air, measured continuously at the plant perimeter and at the 25-mile stations, did not exceed 1.1 percent of the MPC. Iodine-131, ruthenium-106, zirconium-niobium-95, and manganese-54 concentrations in air samples were less than their respective detection limits throughout the entire period.

Deposition of radioactive materials during the second half of 1965 totaled 3.86 nCi/m^2 at plant perimeter locations and 3.47 nCi/m^2 at the 25-mile-radius locations; comparable values for the first half of 1965 were 21.6 nCi/m^2 and 24.7 nCi/m^2, respectively. Deposition at each sampling location is recorded in table 2.

Table 1. Savannah River Plant radioactivity in air, July–December 1965

Filter analyses	Average concentrations, pCi/m^3																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bushfield	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha emitters in air [a] (multiply by 10^{-3})																	
Maximum	1.2	1.3	1.2	1.2	1.1		1.2	1.2	1.1	1.5	1.1	1.2	0.9	1.0	1.3	1.2	
Minimum	0.4	0.4	0.3	0.3	0.3		0.4	<0.3	0.4	<0.3	<0.3	0.3	0.3	0.5	0.3	<0.3	
Average	0.7	0.8	0.7	0.7	0.6	0.7	0.7	0.5	0.7	0.6	0.6	0.7	0.5	0.6	0.6	0.5	0.6
Nonvolatile beta emitters in air [b]																	
Maximum	0.29	0.26	0.28	0.26	0.27		0.14	0.14	0.12	0.14	0.12	0.13	0.13	0.12	0.15	0.12	
Minimum	0.04	0.03	0.03	0.04	0.04		0.04	0.02	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.04	
Average	0.08	0.07	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.07	0.07	0.06
Specific radionuclides in air (averages)	Composite sample						Composite sample										
Cesium-137	0.01						0.01										
Cerium-141	0.02						0.02										
Ruthenium-106	ND						ND										
Zirconium-niobium-95	ND						ND										
Manganese-54	ND						ND										

[a] Sensitivity of analysis—0.3 pCi/m^3; MPC—40 pCi/m^3

[b] Sensitivity of analysis—0.006 pCi/m^3; MPC—100 pCi/m^3

ND, nondetectable.

Table 2. Total fallout deposited, Savannah River Plant, July–December 1965

Radionuclide	Deposition, nCi/m²															
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bushfield	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha *	0.93	1.78	3.36	1.00	1.12	1.62	1.89	2.70	1.04	2.08	1.12	4.36	1.81	1.35	0.85	4.32	2.16
Strontium-90	1.12	1.00	0.85	0.97	1.12	1.00	0.77	0.93	0.66	0.89	0.77	0.97	0.89	1.04	0.89	1.12	0.89
Cesium-137	1.00	1.51	1.08	1.47	1.78	1.35	0.66	1.47	0.89	0.66	0.54	1.31	0.42	1.54	1.16	1.66	1.04
Cerium-144	1.16	1.89	1.35	1.93	2.20	1.70	1.70	1.39	2.32	1.43	1.08	1.81	0.77	1.27	1.62	3.78	1.70
Beryllium-7	8.49	15.8	17.8	15.8	17.0	15.1	7.3	10.4	7.0	3.9	4.2	12.0	2.7	7.3	7.3	17.0	7.7

* Multiply by 10^{-3}

Vegetation

Radioactive contamination of vegetation may result from direct deposition on exposed surfaces or absorption of radioactivity from the soil. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples were collected at seven locations along the Plant perimeter and at nine other locations along a 25-mile radius route. (These are not designated on figure 2.) Samples from each quadrant of the Plant and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha emitters averaged 0.1 pCi/g, dry weight, at the plant perimeter and 25-mile radius locations, as compared to 0.2 pCi/g during the first half of 1965; gamma emitters averaged 22.3 and 17.5 pCi/g, dry weight (including an average of 8 pCi/g of beryllium–7), respectively, as compared to 64 pCi/g and 40 pCi/g for the first half of 1965. Radioisoptic concentrations found in grass samples are presented in table 3. While the exact nature of the alpha activity decrease (about twofold) is not known, the change is commensurate with previously observed changes which appear to be seasonal.

Milk

Milk was sampled at four dairies within a 25-mile radius of the Plant as shown in figure 2. Samples were taken weekly and analyzed for tritium, iodine–131, and cesium–137. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1965 are given in table 4.

The average concentrations of three radionuclides in milk (20 pCi/liter for strontium–90, <5 pCi/liter for iodine–131, and 47 pCi/liter for cesium–137) were consistent with values reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with Plant operations. The average tritium level was less than the sensitivity of the analysis which allows detection of concentrations of 3,000 pCi/liter (1 percent of the MPC).

Algae and fish in the Savannah river

Fish (predominantly bream) and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly

Table 3. Radioactivity on vegetation, July–December 1965

	Concentration, pCi/g, dry weight					
	Alpha	Cesium-137	Cerium-144	Ruthenium-106	Manganese-54	Beryllium-7
Sensitivity of analysis	0.10	0.07	0.32	0.45	0.05	0.60
Plant perimeter (7 locations)						
Maximum	0.40	4.9	15.4	6.4	1.0	12.0
Average	0.13	2.6	7.5	2.2	0.6	9.4
25-mile radius (7 locations)						
Maximum	0.44	1.8	17.8	6.9	0.8	10.1
Average	0.12	1.3	6.0	2.2	0.5	7.5

Table 4. Radioactivity in milk from local dairies, July–December 1965

	Concentration, pCi/liter				
	Aiken	Allendale	North Augusta	Waynesboro Georgia	Major distributors [a]
Tritium [b]					
Maximum	6,000	5,000	7,000	5,000	5,000
Minimum	<3,000	<3,000	<3,000	<3,000	<3,000
Average	<3,000	<3,000	<3,000	<3,000	<3,000
Strontium-90 [c]					
September	13	18	19	18	22
December	18	16	22	23	27
Cesium-137 [d]					
Maximum	105	95	59	103	80
Minimum	<25	<25	<25	<25	<25
Average	50	43	43	51	48

[a] Milk produced in local dairies, but sold by major distributors
[b] Sensitivity of analysis—3,000 pCi/liter; MPC—300,000 pCi/liter
[c] Sensitivity of analysis—1.0 pCi/liter
[d] Sensitivity of analysis—25 pCi/liter; MPC—2,000 pCi/liter

upstream, adjacent to, and downstream from the Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and form a part of the food chain of aquatic organisms. Data from the analysis of fish and algae samples are given in table 5. Beta concentrations in algae and fish adjacent to and downstream from the Plant indicate some Plant contribution. Although measurably higher than similar material collected at the control station 3 miles upstream from the Plant, the slight increase is of no biological significance.

Water monitoring

The Plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 6). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at

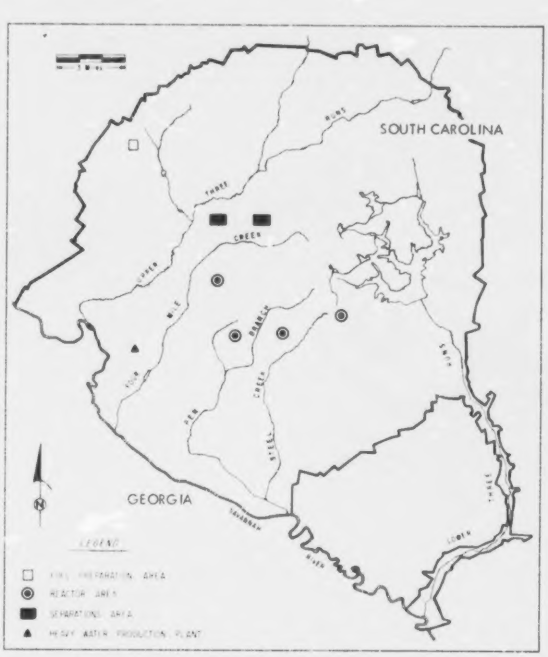

Figure 6. SRP production areas and effluent streams

Table 5. Radioactivity in Savannah River aquatic specimens, July–December 1965

Location	Nonvolatile beta emitters, pCi/g [a]										
	Algae, dry weight				Fish, wet weight						
						Bone			Flesh		
	Number of samples	Maximum	Minimum	Average	Number of samples	Maximum	Minimum	Average	Maximum	Minimum	Average
Control (3 miles upstream from Plant)	2	160	37	98	30	140	ND	27	8	1	4
Along Plant boundary	4	1,250	98	570	30	270	10	58	21	1	6
Highway 301 crossing (10 miles downstream from Plant)	20	740	38	120	30	260	8	51	48	1	9

[a] Sensitivity of analysis—varied due to differing sample size
ND, less than sensitivity of the analysis.

Table 6. Radioactivity in public water supplies

	Concentration, pCi/liter														
	Aiken	Allendale	Augusta	Barnwell	Bath	Blackville	Clearwater	Jackson	Langley	New Ellenton	North Augusta	Sardis	Waynesboro	Williston	Average
Alpha emitters [a]															
Maximum	2.3	0.2	0.5	0.7	4.0	0.7	1.1	24.0	2.3	3.6	0.2	0.4	0.3	1.2	
Minimum	1.0	<0.2	<0.2	<0.2	1.1	<0.2	<0.2	6.0	0.6	0.7	<0.2	<0.2	<0.2	0.2	
Average	1.6	<0.2	<0.2	0.2	2.4	0.3	0.3	13.3	1.4	1.9	<0.2	<0.2	<0.2	0.6	1.7
Nonvolatile beta emitters [b]															
Maximum	5	5	8	7	11	4	5	42	6	18	6	14	17	4	
Minimum	<4	<4	<4	<4	<4	<4	<4	8	<4	4	<4	<4	<4	<4	
Average	<4	<4	4	<4	8	<4	<4	25	4	8	<4	4	5	<4	6

[a] Sensitivity of analysis—0.2 pCi/liter; MPC—10 pCi/liter
[b] Sensitivity of analysis—4.0 pCi/liter; MPC—3,000 pCi/liter

a location about 90 miles below the Savannah River Plant site. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns are collected and analyzed monthly. Concentrations of alpha activity (1.7 pCi/liter) and beta activity (6 pCi/liter) are essentially the same as those observed before plant startup in 1951. Analytical results are given in table 6.

River water, analyzed weekly, was sampled continously at four locations (upstream, adjacent to, and as far as 10 miles downstream) as shown in figure 2. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 7; average concentrations of specific radionuclides found in the river water during July–December 1965 are in table 8.

Table 7. Radioactivity in Savannah River water July–December 1965

	Concentration, pCi/liter			
	Control (3 miles upstream from Plant)	Plant perimeter		Highway 301 (10 miles downstream from Plant)
		1	2	
Alpha emitters [a]				
July–December 1965:				
Maximum	0.7	0.7	0.4	0.3
Minimum	<0.2	<0.2	<0.2	<0.2
Average	0.2	<0.2	<0.2	<0.2
January–June 1965:				
Average	0.3	0.2	0.2	<0.2
Nonvolatile beta emitters [b]				
July–December 1965:				
Maximum	20	58	37	31
Minimum	<4	<4	4	<4
Average	6	18	13	10
January–June 1965:				
Average	8	13	13	10

[a] Sensitivity of analysis—0.2 pCi/liter; MPC—10 pCi/liter
[b] Sensitivity of analysis—4.0 pCi/liter; MPC—3,000 pCi/liter

Table 8. Average concentration of radionuclides in Savannah River water, July–December 1965

Radionuclide	Concentration, pCi/liter			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium	600	1,000	12,400	4.1
Ruthenium-103, -106	3.2	<3.2	<3.2	<0.10
Cerium-141, -144	2.5	<2.5	<2.5	<0.08
Cesium-134, -137	0.6	<0.6	2.2	0.11
Neptunium-239	0.9	<0.9	<0.9	<0.003
Barium-lanthanum-140	1.6	<1.6	<1.6	<0.02
Zirconium-niobium-95	0.5	<0.5	<0.5	<0.02
Chromium-51	4.3	<4.3	8.6	0.001
Strontium-89	0.3	<0.3	<0.3	—
Iodine-131	0.5	<0.5	0.7	—
Strontium-90	0.01	1.2	2.1	—
Cobalt-60	1.4	<1.4	<1.4	<0.01
Zinc-65	1.1	<1.1	<1.1	<0.01
Manganese-54	0.4	<0.4	<0.4	<0.001

Cesium–137, strontium–90, chromium–51, iodine–131, tritium, and trace amounts of zirconium-niobium–95, released mainly from reactor areas, were the radionuclides of plant origin detectable in river water at the downstream location. The average concentration of zirconium-niobium–95 was less than the sensitivity of the analysis. Strontium–90 and tritium from worldwide fallout were also detected in river water upstream from the Plant. Average concentrations of all radionuclides found in river water during July–December 1965 were only small fractions of the permissible concentrations. The tritium concentrations in finished water collected from the Beaufort-Jasper Water Plant averaged 5,400 pCi/liter (1.8 percent of the MPC) during the 6-month period.

Tritium (^3H), a beta emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water moderator in the reactors. Chromium-51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). The concentrations of tritium and chromium-51 in river water averaged 4.1 percent and 0.001 percent of their respective MPC. Average concentrations of all radionuclides found in river water during July–December 1965, as shown in table 8, were only small fractions of the permissible concentrations.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with portable Geiger-Mueller survey instruments. July–December 1965 data in table 9 are characteristic of individual station observations during the past several years; the readings are not precise, but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown are within the variability anticipated due to differences in normal background and in instrument response characteristics.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation, or was obscured by worldwide fallout from nuclear weapons testing during past years. Beta activity in air, which shows no relationship to plant operations, was about one-fifth that for the same period of 1964. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of radionuclides in river water did not exceed 4.1 percent of the maximum permissible concentrations.

Table 9. Environmental gamma radiation, Savannah River Plant, July–December 1965

	Exposure, mR/day																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Maximum	0.62	0.54	0.49	0.43	0.41		0.40	0.39	0.51	0.49	0.41	0.44	0.40	0.39	0.41	0.40	
Minimum	0.25	0.25	0.32	0.24	0.23		0.20	0.21	0.21	0.24	0.26	0.22	0.22	0.19	0.27	0.23	
Average	0.39	0.34	0.37	0.32	0.33	0.35	0.32	0.29	0.32	0.35	0.33	0.33	0.32	0.30	0.35	0.32	0.32

Previous coverage in *Radiological Health Data and Reports:*

Issue	Period
July–December 1961	September 1962
Calendar Year 1962	August 1963
Calendar Year 1963	August 1964
January–June 1964	February 1965
July–December 1964	August 1965
January–June 1965	February 1966

Section V. Technical Notes

PLUTONIUM IN AIRBORNE PARTICULATES NOVEMBER 1965–MARCH 1966

J. Russell, H. Levine, and *R. Schneider*[1]

The Radiation Surveillance Network (RSN) of the Division of Radiological Health, Public Health Service, located at Rockville, Maryland, initiated routine analysis for plutonium in air particulates during 1965 as part of its mission to establish, maintain, and operate a national surveillance network to measure radioactivity in the environment (*1*). Plutonium has been injected into the atmosphere by the detonation of nuclear devices (*2*), and its determination in air is of interest because inhalation is believed to be the principal route of nonoccupational exposure (*3*).

Air filters from 11 RSN stations are analyzed monthly for plutonium. Each daily filter is counted for gross beta activity and for gamma emitters by gamma spectroscopy 4 or 5 days after collection. For plutonium analysis, a monthly composite is made of one half of each individual sample for each station. Each composite, representing 20,000 to 30,000 cubic meters of air, is analyzed by gamma spectroscopy prior to the plutonium analysis.

The air particulate samples are collected on carbon-loaded cellulose filters. The filter is mounted on the vacuum side of a positive displacement lobar impeller pump in a special filter holder with orifice, designed by the RSN staff. Air flow is determined by a gauge which reads the pressure drop across the orifice and is calibrated in cubic feet per minute.

The air filters are ashed in a platinum crucible, brought completely into solution with a nitric acid-hydrofluoric acid treatment, converted to the chloride ion and brought to volume in a volumetric flask. The solution is then divided into two aliquots, 70 percent and 30 percent, and each aliquot analyzed and counted separately for total plutonium according to the procedure of Levine and Lamanna (*4*). The total activity is the sum of the results for both aliquots. The chemical yield of the analytical procedure is approximately 80 percent as determined by spiked samples. The samples are counted for 1,000 minutes in a 2-inch-diameter, 0.080 mg/cm^2-window proportional counter.

The counting error at the 95-percent confidence level is less than 10 percent for most of the samples, and the accuracy of the air flow measurement is estimated to be within 5 percent. The precision of the analytical procedure is estimated to be approximately 20 percent at the 1 pCi activity level, based upon the results of the two aliquots.

The results for November 1965 through March 1966, in picocuries per 1,000 cubic meters, are presented in table 1. It should be noted that the stations selected for plutonium analysis were changed from El Paso to Austin, Texas, and from Spokane to Seattle, Washington, beginning in February 1966.

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[1] Mr. Russell is chief, Radiation Surveillance Network; Mr. Levine is chemist, Radiation Surveillance Network; and Mr. Schneider is experimental physicist, Office of Assistant Chief for Technical Development, all in the Technical Oprations Branch, Division of Radiological Health, PHS.

Table 1. Plutonium in airborne particulates November 1965–March 1966 [a]

Station location	Plutonium content, pCi/m³				
	Nov 1965	Dec 1965	Jan 1966	Feb 1966	Mar 1966
Alaska: Anchorage	0.048	0.061	0.077	0.105	0.074
Arizona: Phoenix	0.114	0.089	0.144	0.181	0.041
Colorado: Denver	0.090	0.079	0.090	0.107	0.085
Hawaii: Honolulu	0.045	0.052	0.104	0.085	0.070
Louisiana: New Orleans	0.066	0.096	0.084	0.113	0.138
Maryland: Rockville	0.054	0.069	0.078	0.079	0.066
New York: Buffalo	0.051	0.038	0.068	0.051	0.078
North Carolina: Gastonia	0.095	0.145	0.086	0.096	0.120
South Dakota: Pierre	0.094	0.081	0.089	0.080	0.089
Texas: Austin	—	—	—	0.137	0.153
El Paso	0.039	0.069	0.034	—	—
Washington: Seattle	—	—	—	0.043	0.080
Spokane	0.057	0.056	0.048	—	—

[a] Plutonium includes plutonium-238, plutonium-239, and plutonium-240.

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(3) KREY, P. W., D. BOGEN, and E. FRENCH. Plutonium in man and his environment. Nature 195:263-265 (July 21, 1962).

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REPORTED NUCLEAR DETONATIONS, JULY 1966

During July 1966, one U.S. nuclear test at the Nevada Test Site was announced by the Atomic Energy Commission, and two French nuclear tests in the Pacific were announced by French authorities.

The U.S. test was in the low-yield range (equivalent force of less than 20 kilotons of TNT), conducted underground on July 28, 1966. This test was part of the Commission's "Plowshare Program" to develop peaceful uses for nuclear explosives. In this instance, the test was one of a series to develop devices for use in possible later excavation experiments.

French test Headquarters at Tahiti announced that a plutonium fission device, described as one of "tactical" size, was exploded July 2, 1966, over a lagoon off the uninhabited Pacific atoll Moruroa, about 750 miles southeast of Tahiti. Another French nuclear test conducted in the same area on July 19, 1966, involved a nuclear device dropped from an airplane. The French announcements of the test indicated that this device would be one of low yield.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

STRONTIUM-90 CONCENTRATIONS OBSERVED IN U.S. PASTEURIZED MILK COMPARED WITH PRECIPITATION AND STRONTIUM-90 IN DEPOSITION AND IN SOIL, 1960–1963. *H. L. Fisher, J. R. Coleman,* and *R. D. Grundy. Radiological Health Data and Reports,* Vol. 7, August 1966, pp. 427–439.

Annual averages of strontium-90 concentrations in milk were compared with precipitation, strontium-90 deposition, and strontium-90 in soil for the years 1960 to 1963 on the basis of a linear relationship. This relationship may be useful for limited predictions of future strontium-90 concentrations in milk. As expected, higher concentrations of strontium-90 were found in milk from areas of higher concentrations of strontium-90 in soil, and higher milk concentrations seemed to be associated with increased rainfall. Although it was clear that increased deposition of strontium-90 was related to its concentration in milk, variations in the relationship remain to be studied on the basis of the specific transport mechanisms involved.

KEY WORDS: deposition, milk, precipitation, soil, strontium-90.

RADON-222 IN NATURAL GAS. *Louis A. Bunce* and *Frank W. Sattler. Radiological Health Data and Reports,* Vol. 7, August 1966, pp. 441–444.

In the preoperational phase of a study to determine the effect of an underground nuclear detonation on radon levels in natural gas, baseline levels of radon-222 have been measured during 1965 in natural gas from 307 producing wells in the proposed test area. Average radon-222 levels in natural gas from formations sampled varied from 2.7 to 66.9 pCi/liter, with a maximum observed value of 158.8 pCi/liter. Assuming combustion in a room without discrete ventilation, radon-222 buildup from an original fuel concentration of 50 pCi/liter could produce a room concentration of 1 pCi/liter. This estimated concentration equals the maximum exposure level permitted by regulations of the State of New Mexico (based on NCRP limits) under conditions on continuous or general population exposure. Normal use of natural gas would not be expected to produce radon-222 concentrations in excess of these recommended limits.

KEY WORDS: Colorado, natural gas, New Mexico, Project Gasbuggy, radon-222.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 9 September 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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Public Health Service ● Division of Radiological Health

Reports

POLONIUM-210 IN TOBACCO PRODUCTS AND HUMAN TISSUES

E. S. Ferri and *E. J. Baratta*[1]

Using a "smoking machine," tobacco smoke was collected. It was found that polonium-210 concentrations in the tobacco smoke accounted for about 11 to 30 percent of that found in the total product, depending on the type of filter used. Analyses of human tissues indicated that the lung, blood, and liver, in that order, of smokers contained more polonium-210 than the corresponding organs of nonsmokers.

The possibility that polonium-210 in tobacco may be implicated in the origin of lung cancer prompted studies on the levels of this and related radionuclides in several brands of cigarettes (*1,2*). To determine whether the polonium-210 was present independently or in equilibrium with its precursors, radium-226 and lead-210 levels were also measured. In addition, selected samples of human organs from smokers and nonsmokers were measured for polonium-210 concentrations to determine whether a difference could be detected due to smoking.

Products investigated

Various major tobacco product types chosen for the study included nonfiltered cigarettes, filtered cigarettes, and cigarettes containing tobacco treated for removal of tars and nicotine. Although normally considered a lesser health hazard to the lungs, cigars and pipe tobacco were also assayed for purposes of comparison.

Methodology of analysis

"Classical" separations were performed on tobacco ashed at 450°C. for the analysis of radium-226 and lead-210. Radium-226 was determined by emanation, collection, and counting the gaseous daughter, radon-222(*3*). Lead-210 was isolated using an anion exchange resin, precipitated as a chromate, and the ingrown daughter, bismuth-210, counted. Lead-210 was also determined by collecting the bismuth-210 on an anion resin, eluting, precipitating as an oxychloride, and counting. Purity of recovery is ascertained by decay observations.

Because polonium-210 is volatile at dry ashing temperatures, samples were wet ashed with nitric and perchloric acids. The resulting solution was made $0.5N$ in hydrochloric acid, and the polonium-210 was spontaneously deposited on a silver disk (*4*). Purity and activity were observed on an alpha spectrometer.

All samples analyzed for polonium-210 were electroplated on silver disks from a hydrochloric acid solution. To evaluate the plating efficiency, a known amount of polonium-210 tracer was added to previously depleted samples. An average of 96.9 ± 3.6 percent plating efficiency was obtained. The recoveries from the various media demonstrated that there was no significant loss of polonium-210 during the plating process.

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[1] Mrs. Ferri is the assistant director, and Mr. Baratta is the director of Analytical Services, Northeastern Radiological Health Laboratory, Division of Radiological Health, Public Health Service, Winchester Massachusetts 01890.

Results of analysis

Table 1 illustrates that the parent radium-226 is not in equilibrium with its daughters, lead-210, bismuth-210, and polonium-210. The high lead-to-radium ratios indicate that lead-210 independently reaches the plant via direct uptake from the soil and/or deposition from the precursor radon-222 in the air. The derivation of the lead-210, and consequently polonium-210, is uncertain. Marsden (*5*), using autoradiographic techniques to measure surface activities of tobacco leaves, has stated that polonium from fallout is minor compared to uptake from the soil through roots. Gregory (*6*) suggested that in insular or coastal growing areas the natural radon emanating from the soil was dispersed, resulting in lower concentration in that region.

Table 1. Radionuclides in tobacco products (cigarette, cigar, pipe tobacco)

Type	Radium-226	Lead-210	Polonium-210	Lead-210/radium-226
Cigarettes, pCi/cigarette				
Nonfilter	0.15	0.44	0.43	2.9
Nonfilter	0.15	0.42	0.37	2.8
Filter				
Cellulose	0.17	0.33	0.32	1.9
Cellulose and charcoal	0.12	0.49	0.48	4.1
Cellulose, charcoal, treated	0.11	0.33	0.34	3.0
Cellulose, pipe tobacco	0.11	0.35	0.34	3.2
Cigars, pCi/cigar				
5¼", 7.8 grams	0.74	3.55	3.60	4.0
Pipe tobacco, pCi/g				
Regular cut	0.10	0.41	0.20	4.3

The values for radium-226 and polonium-210 agree with those reported by Tso, Hallden, and Alexander, for various domestic tobaccos (*7*). All cigarettes and cigars show lead-210 and polonium-210 to be in equilibrium. This is probably the result of the approximate 2-year "aging" time employed in processing tobacco for cigars and cigarettes. The sample of pipe tobacco showed only about 50 percent equilibrium. This indicates the possibility that the brand chosen had been "cured" and "aged" a minimum length of time, and had been on the vendor's shelf for a short time.

Smoking machine

Of primary interest as a health hazard from smoking are those nuclides which are volatile at the temperature of burning tobacco. Before this hazard can be assessed, it is necessary to determine the levels of activity in the smoke, and thus inhaled and/or deposited in the mouth, bronchial tract, and lungs of the smoker.

To collect the smoke as normally inhaled, a smoking apparatus (shown schematically in figure 1) which simulates smoking, was devised and tested. The polonium-210 which has volatilized, and the nicotine and tars, are collected on two filters (glass wool, and 0.45μ Millipore) followed by a hydrochloric acid trap. To simulate puffing, the system is connected to a vacuum line and airflow is regulated by flowmeter, vacuum gauge, electronic timer, and solenoid valve. The smoking rate was set at 10 puffs per cigarette, with each puff of 3 seconds duration, and 26-second intervals between puffs. The average smoke flow rate was 18 ml/second (at standard conditions of temperature and pressure). Sidestream smoke is collected by placing a bottle over the burning cigarette, and a filter, connected to a vacuum line, is attached to the bottle. Thus, when smoke is not being drawn through the cigarette, it collects on the filter in the flask.

A comparison was made between the butts and ashes obtained from filters, nonfilters, and treated-tobacco cigarettes smoked by the machine and by three individuals (table 2). The comparison indicates that the smoking machine is a good approximation of actual smoking and can be used to determine the distribution of radionuclides between cigarette smoke and residue.

Table 2. Percentage polonium-210 in cigarette butts, ashes, and filters from smokers versus smoking machine

Type of cigarette	Percent polonium-210	
	Smokers	Smoking machine
Nonfiltered	ª 48 ±7	ª 47 ±8
Filtered, including filter	50 ±8	53 ±9
Treated, including filter	51 ±8	50 ±8

ª Counting error is 2 standard deviations, expressed as percent.

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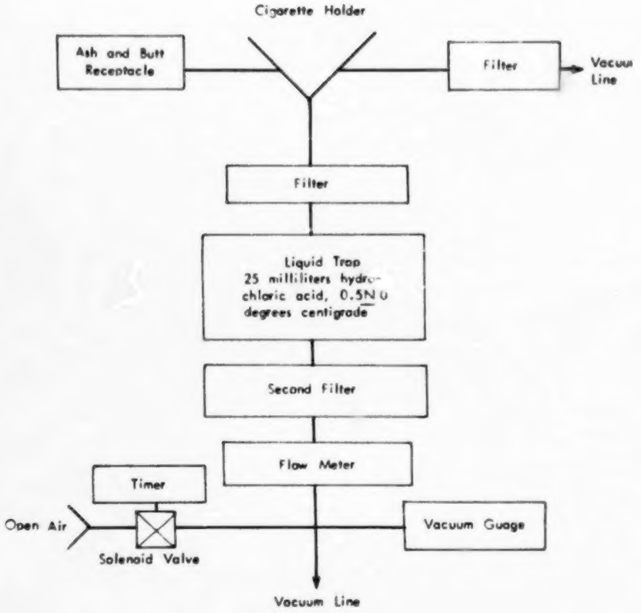
Cigarette Holder
Ash and Butt Receptacle
Filter
Vacuum Line
Filter
Liquid Trap 25 milliliters hydrochloric acid, 0.5N 0 degrees centigrade
Second Filter
Flow Meter
Timer
Open Air
Solenoid Valve
Vacuum Guage
Vacuum Line

Figure 1. Flow diagram of the smoking machine

Polonium–210 in cigarette smoke and residue

With the smoking machine, material balances for polonium–210 were obtained on four major brands of filtered and nonfiltered cigarettes. The unsmoked cigarette was analyzed for polonium–210. The smoked cigarette was analyzed for polonium–210 in the (a) smoke inhaled, (b) sidestream smoke (smoke not inhaled), (c) unsmoked tobacco and ash, and (d) filter. Each analysis was performed on smoke and residue from one package, or 20 cigarettes. To normalize the data for varying quantities of tobacco in each cigarette, the results are given in picocuries per gram of tobacco (table 3). No attempt was made to determine the polonium–210 expired in the exhaled smoke or reaching the mouth or lungs via the inhaled smoke.

All brands tested showed approximately the same activity per gram in the total cigarette. However, quite diverse activities were evidenced in the inhaled smoke portion. With the exception of a filtered cigarette containing pipe tobacco as a filler, the filtered cigarettes contained 33 to 50 percent less in the inhaled smoke than did nonfiltered cigarettes. The ratio of sidestream to mainstream smoke in the nonfiltered brands appears to be close to unity, whereas the filtered brands demonstrate

Table 3. Polonium-210 material balance, pCi/g tobacco [a]

Sample	Polonium-210 concentration, pCi/g			
	Non-filter	Filter type		
		Cellulose	Cellulose, charcoal, treated	Cellulose, pipe tobacco
Total cigarette	0.411	0.403	0.410	0.357
Inhaled smoke	0.091 (22.2%)	0.061 (15.1%)	0.045 (11.0%)	0.109 (30.7%)
Sidestream smoke	0.100 (24.5%)	0.133 (32.9%)	0.168 (40.8%)	0.116 (32.4%)
Butt and ash	0.191 (46.7%)	0.157 (38.8%)	[b] 0.206 (50.3%)	0.115 (32.2%)
Filter	—	0.055 (13.7%)		0.031 (8.8%)
Material balance, % [c]	93.4 ±5.4	100.5 ±5.2	102.1 ±6.3	104.1 ±5.2

[a] Numbers in parentheses are percentages of polonium-210 relative to that of original product.
[b] Includes filter.
[c] Total error term is one standard deviation.

ratios of 2.1 to 3.7. Again the pipe tobacco filler exhibits activities close to a nonfiltered cigarette. Distribution of the polonium in the various residues of nonfiltered cigarettes agrees well with the findings of Rajewsky and Stahlhofen (*8*). It would therefore appear that different filtering mechanisms, whether of artificial material or of the tobacco itself, and possibly the cut, are contributing to the variation in activities found in inhaled smoke.

Polonium–210 in human organs

To determine if polonium–210 from smoking concentrates in various organs of the human body, specimens of soft tissue and bone of smokers and nonsmokers were analyzed and compared (table 4). Samples were obtained through autopsies at local hospitals, and smoking histories were available. Soft tissue chosen for the study were lung, liver, kidney, heart, and psoas muscle. Blood drained from the heart was used for fluid tissue, and spine for the skeletal tissue. The age of the smokers ranged from 36 to 80 years; of nonsmokers from 47 to 76. Smokers, as referred to in table 4, were composed of those people smoking one to three packs of cigarettes per day for 22 to 40 years, and 10 cigars per day for 10 years.

Table 4. Polonium-210 in human organs

Tissue	Concentration, pCi/100 g wet tissue		
	Smoker	Nonsmoker	Smoker/nonsmoker
Lung	[a] 0.65 ± .12 [b] (14)	0.31 ± .05 (7)	2.10 ± .51
Liver	1.25 ± .25 (12)	1.03 ± .18 (10)	1.21 ± .32
Kidney	0.79 ± .15 (12)	0.80 ± .19 (10)	0.99 ± .30
Muscle (psoas)	0.08 ± .025 (4)	0.08 ± .025 (4)	1.00 ± .45
Blood	0.19 ± .07 (6)	0.13 ± .04 (5)	1.46 ± .63
Bone (spine)	3.16 ± .76 (6)	3.05 ± .38 (6)	1.04 ± .28
Heart	0.24 ± .07 (12)	0.26 ± .07 (10)	0.92 ± .36

[a] Figures in parentheses are number of samples analyzed.
[b] Total error term is one standard deviation.

Our tests indicate the lung, blood, and liver of smokers, in that order, contain more polonium–210 than the corresponding organs of nonsmokers. The polonium–210 in the kidney, heart, muscle (psoas), and bone (spine), appears to be about the same level in smokers and nonsmokers. Measured activities and ratios of the lungs of smokers and nonsmokers are comparable to values obtained by Rajewsky and Stahlhofen (*8*).

Acknowledgment

The authors wish to acknowledge and thank Mr. John Apidianakis for his invaluable assistance on this project.

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MAINE'S EXPERIENCE WITH A STATE-OPERATED PERSONNEL MONITORING PROGRAM FOR RADIATION WORKERS

J. W. Fuller[1]

In a 10-year program of monitoring exposures of radiation workers, Maine's Department of Health and Welfare found increasing acceptance of its free film badge services. Results of findings are outlined. Review of film badge exposure records during examination of over 5,000 film badges in 1965 indicated that exposure of the great majority of individuals was relatively low. Periodic radiological health surveys of installations using independent film badge services indicated that no exposures to individual workers exceeded 100 milliroentgens per week.

Maine's Department of Health and Welfare has operated a statewide film badge program for personnel monitoring of radiation workers since 1956. Although the State of Illinois in recent years has had a central file on radiation exposures among radiation workers, and some States have provided film badges on a limited scale during certain phases of their radiological health programs, Maine is the only State, so far as is known, that provides the film badges as well as a central file of the exposure findings on a continuing basis.[2]

Maine, whose current population is approximately one million, initiated this program for the following reasons:

1. Only one hospital and one industrial firm utilized personnel monitoring for radiation workers in 1954.
2. Preliminary surveys had revealed several examples of inadequate shielding and poor operating procedures among radiation users in the State.
3. Some dentists and veterinarians showed evidence of radiation injuries. It was felt that many other radiation personnel may have been overexposed to radiation as well, although signs of injury were not overt.
4. It was believed that a film badge service would provide a record of radiation exposures which would be useful in workmen's compensation cases where claims of radiation injury might be contested.
5. It was believed that a film badge service would develop an awareness of the potential hazards of radiation, would promote interest in radiation protection for both X-ray personnel and patients, and would make the introduction of State rules and regulations pertaining to radiation a much easier step.

As the availability of this service became known, the use of the State's film badges by various radiation installations in Maine gradually increased from a total of 2,280 film badges

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[2] Additional information about the State's film badge program, or other aspects of the radiological health program, is available by writing to the Department of Health and Welfare, Division of Sanitary Engineering, State House, Augusta, Maine 04330.

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per year in 1956 to 5,086 in 1965. During fiscal year 1965, 580 individuals, representing about 75 percent of the workers in Maine occupationally exposed to ionizing radiation (other than dentists, dental assistants, and dental hygienists), took advantage of the State's film badge program. Of these 580 people, 100 were part-time users and 409 were full-time users who wore the badges either for 2- or 4-week periods, depending on their workload, and 171 were doctors or dentists who wore the film badges for short periods to evaluate the radiation hazard in their offices.

In recent months, the system has included 405 physicians (M.D.'s and osteopaths), X-ray technicians and nurses employed in radiation work in hospitals; 16 dentists, dental assistants, and dental hygienists; 18 physicians and technicians using X-ray equipment in clinics and offices; a few other X-ray workers; and 141 isotope users. About 24 percent of the workers monitored in the program use radioactive materials licensed by the U.S. Atomic Energy Commission.

Stainless-steel film badge holders were purchased initially for use for this program. They were soon found to be unsuitable by nurses and female X-ray technicians because of their weight and bulk. Plastic film badge holders were subsequently purchased and used in the non-industrial radiation settings. However, the stainless-steel film badge holders are still used by the workers in industrial radiation installations. Each batch of 2,000 films purchased three times a year is calibrated by using an NBS certified radium needle for gamma radiation, a slug of natural uranium for beta radiation, and an X-ray machine with 2.5 mm of aluminum operated at 75 kVp for X-ray, as the majority of our film badge users are operating their equipment in the 75 kVp range.

Ordinarily the film badges are worn for periods of 2 weeks by groups with heavy workloads, and monthly by all others. The State pays postage for the film badges sent to the users and the users pay postage for the exposed film badges returned to the State. When the film badges have been processed, the Department of Health and Welfare institutes a follow-up of any unusual exposure.

A copy of the report is returned to the users; however, the original report of the badge reading and the film badge itself are maintained in permanent files in the Department of Health and Welfare. It was observed that beyond a 3-year period, the image on these film badges had begun to fade; and after 5 years, the image had faded so badly that the value of the film as a record is very questionable. Table 1 gives the average occupational radiation exposures for each year calculated for the monitored radiation personnel, assuming that all such persons have worn their badges 6 months or more each year of the exposure period.

Table 1. Average film badge reading per person

Year	Number of users	Average reading [a] (mR/month)
1956–1957	131	18
1957–1958	145	35
1958–1959	158	19
1959–1960	167	50
1960–1961	200	33
1961–1962	230	9
1962–1963	241	10
1963–1964	258	21
1964–1965	306	20

[a] Sensitivity is approximately 1 mR.

It should be taken into consideration that the workload of most hospitals has increased in the last few years; therefore, the reduction in exposure rate received was not as clearly shown by table 1 as if the workload had been constant. Where individual hospitals replaced their old buildings and installed properly shielded X-ray equipment, the reduction was greater.

Somewhat higher exposures have occurred among X-ray personnel employed in some of the large, old hospitals in the State. It is felt that these slightly higher exposures are due to the relatively heavy X-ray workloads that have been imposed on obsolescent equipment and facilities, and that the situation will be improved as modern hospitals are built to replace the old ones. Generally smaller radiation exposures have been found among dentists, dental assistants, and dental hygienists; industrial radiographers doing cabinet radiography; hospital and research laboratory workers using AEC-licensed nuclides; and X-ray personnel employed in small hospitals where the X-ray workload has been light.

Under the State-operated program, 5,086 badges were processed during fiscal year 1965, 34 of which gave indications of greater than 100 mR/week, the short-term limit on radiation exposure used for program purposes. No individual, however, had an indicated exposure in excess of 5 R for the year. Table 2 shows the distribution of badge readings. Followup of the indicated overexposure cases usually revealed that good practices had been breached, such as a technician holding a subject during radiography. In some cases, there were reasons to believe the film badge had been carelessly exposed by leaving it, improperly, near a radiation source.

Table 2. Distribution of badge readings for fiscal year 1965

mR/week	Number of film badges
<2	3,127
2–24	1,688
25–49	161
50–74	41
75–99	24
100–199	23
200–299	16
300–399	1
400–499	2
500–599	2
>2,000	1
Total	5,086

A relatively small number of radiation installations in Maine utilize film badge services other than the service available from the State. These installations are not required to report the film badge findings. However, each user must maintain records of the findings of his film badge program, and these records are reviewed by State personnel during periodic radiological health surveys. No instance of exposures of more than 100 mR/week to ionizing radiation has come to light through this record system.

There are many individual users of X-ray equipment in Maine who are not monitored on a regular basis for radiation exposures. These include about 610 dentists and dental technicians, about 325 individuals (physicians, technicians, and others), such as those working in 25 small hospitals and private medical offices where X-rays are used only occasionally, and 82 persons who work around thickness gauges in which AEC-controlled nuclides are used. Over the 10-year period, 69 dentists and 107 dental technicians have worn our film badges. Of these, only seven dentists and 16 dental technicians wore the badges for more than 2-year periods. The majority were worn for only about 6 months; and in all cases the dose received per week was from less than 2 mR to 15 mR, with an average of 3 mR per week for all badges worn. Periodically a determination has been made by radiation inspectors from the Department of Health and Welfare that the radiation level in the positions occupied by these radiation workers during their employment is less than 25 percent of the permissible dose to individuals in a controlled area[3] and continuous personnel monitoring is not considered to be essential. Should the mode of operation of the radiation installations change, however, film badges are available on request to determine whether the levels of radiation exposure are sufficiently increased to warrant a regular monitoring program. Many of the 25 smaller hospitals will reinstitute personnel monitoring among radiation workers as one of the conditions of participation for hospitals under the Medicare Program. Personnel monitoring is not required if there is adequate evidence that the exposures will not exceed 25 percent of the permissible dose to individuals in a controlled area.[3]

There are about 77 radiation installations in Maine using the State's badge program. These installations include 49 hospitals, 8 dental offices, 9 medical clinics and physicians' offices, 2 veterinarians, 2 industries, 2 colleges, and 1 large research laboratory, as well as 4 State agencies.

There are about 248 radiation workers in Maine, including approximately 25 students in a one-semester course in a college, who use materials controlled by the Atomic Energy Commission. Of these, about 141 (56 percent) are monitored for radiation exposures on a regular basis through the State's film badge program.

By way of comparison, there are about 1,350 radiation workers using radium and the types of X-ray equipment used in industry, educational institutions, and the practice of medicine, dentistry, and other forms of the healing arts.

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[3] "State of Maine Rules and Regulations Relating to Protection," Section B-10, page 23, indicates a permissible level of 100 mR/week.

Approximately 440 (32 percent) are monitored by the State's program.

The radiation exposures associated with medical and dental examinations, when radiation workers are patients under the care of a practitioner of the healing arts, are not assessed under this program.

Prior to the institution of this program in 1956, there had been several instances of radiation injuries among dentists and veterinarians in particular, such as severe radiation injuries of the fingers. Since 1956 there has been no known instance of occupationally related radiation injury among the radiation workers in the State of Maine. This improvement is thought to be due in part to the increased awareness of the hazards of ionizing radiation brought about by the State's personnel monitoring program.

The followup program dealing with suspiciously high readings on the film badges has uncovered a few instances of poor radiation practice. One advantage of the approach used in Maine is that the Department of Health and Welfare, through its operation of the film badge program, is alerted to possible overexposures relatively soon after they occur. This permits prompt followup and facilitates a reconstruction of the circumstances that lead to higher-than-usual badge reading.

Averaged out for the population of the State of Maine, the contribution to the genetic pool from occupational exposure among its radiation workers amounts to somewhat less than 1 mR/year. This is to be compared against radiation exposures amounting to about 100 mR/year from natural background and exposures perhaps in the range of from 50 to 100 mR, due to irradiation of members of the population incidental to the practices of the healing arts in the State.

Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide, however, an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission of Radiological Protection (*5,6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

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(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1965	June 1966

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1. Pasteurized Milk Network
May 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).

The results for May 1966 and for the first quarter of 1966 are presented in table 1. The

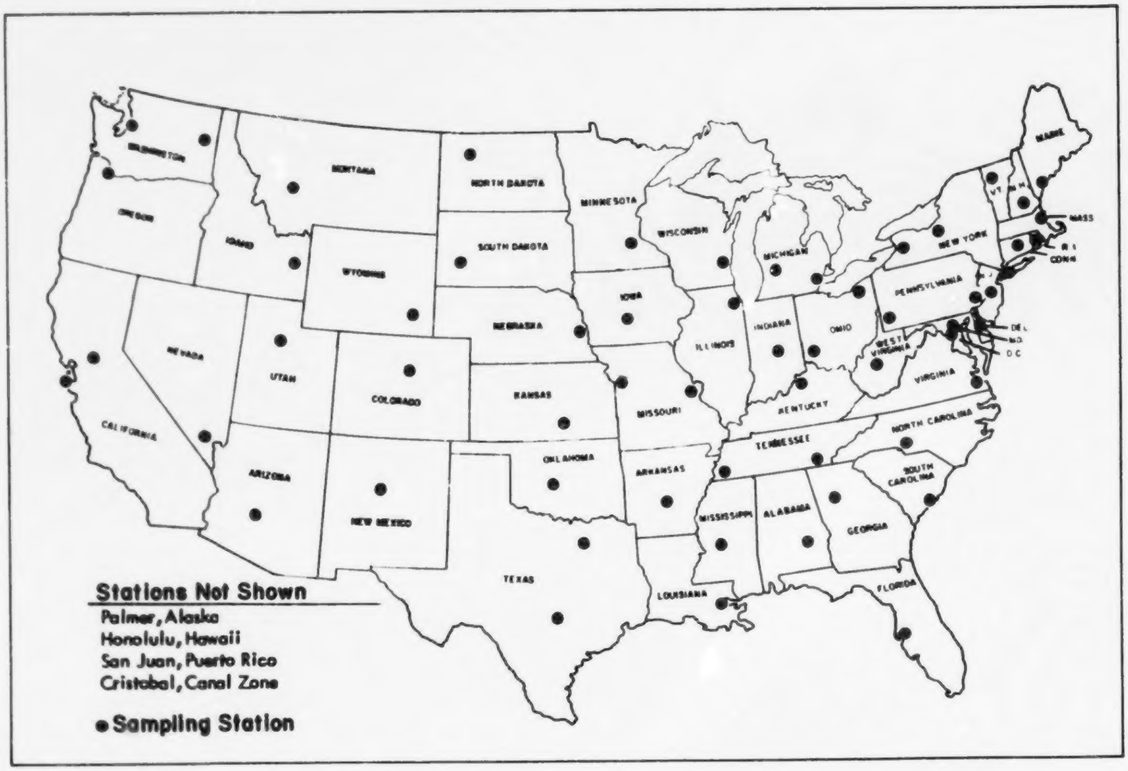
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VT
N.H.
MAINE
MASS
R.I.
CONN
DEL
MD
D.C.
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average radionuclide concentration in pasteurized milk for the first quarter and May 1966 [a]

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)	
		First quarter 1966	May 1966	First quarter 1966	May 1966	First quarter 1966	May 1966	First quarter 1966	May 1966	First quarter 1966	May 1966
Ala:	Montgomery	<5	<5	12	12	25	30	0	20	0	0
Alaska:	Palmer	<5	<5	14	15	40	45	0	20	0	0
Ariz:	Phoenix	<5	<5	4	2	15	10	0	0	0	0
Ark:	Little Rock	<5	25	26	38	40	50	0	80	0	20
Calif:	Sacramento	<5	<5	6	7	15	15	0	0	0	0
	San Francisco	<5	<5	7	8	20	20	0	0	0	0
C.Z:	Cristobal	<5	<5	4	4	25	20	0	0	0	0
Colo:	Denver	<5	<5	11	11	25	25	0	0	0	0
Conn:	Hartford	<5	<5	11	11	40	40	0	0	0	0
Del:	Wilmington	<5	<5	13	17	40	40	0	10	0	0
D.C:	Washington	<5	<5	12	14	30	30	0	0	0	0
Fla:	Tampa	<5	<5	11	11	105	115	0	10	0	0
Ga:	Atlanta	<5	5	19	21	45	45	0	20	0	0
Hawaii:	Honolulu	<5	<5	5	7	35	30	0	0	0	0
Idaho:	Idaho Falls	<5	<5	13	15	45	40	0	0	0	0
Ill:	Chicago	<5	<5	11	14	35	35	0	0	0	0
Ind:	Indianapolis	<5	10	12	13	30	30	0	50	0	10
Iowa:	Des Moines	<5	<5	14	17	30	30	0	20	0	0
Kans:	Wichita	<5	<5	13	15	20	25	0	30	0	0
Ky:	Louisville	<5	10	16	21	25	25	0	20	0	0
La:	New Orleans	<5	<5	29	31	40	45	0	10	0	0
Maine:	Portland	<5	<5	15	16	65	70	0	0	0	0
Md:	Baltimore	<5	<5	13	16	30	30	0	0	0	0
Mass:	Boston	<5	10	14	15	60	65	0	0	0	0
Mich:	Detroit	<5	<5	11	12	35	35	0	10	0	0
	Grand Rapids	<5	<5	14	15	45	50	0	0	0	0
Minn:	Minneapolis	<5	<5	20	24	40	45	0	10	0	0
Miss:	Jackson	<5	5	23	29	25	35	0	10	0	0
Mo:	Kansas City	<5	15	15	18	20	25	0	50	0	0
	St. Louis	<5	35	15	20	30	30	0	60	0	0
Mont:	Helena	<5	<5	15	15	55	55	0	0	0	0
Nebr:	Omaha	<5	<5	15	17	25	30	0	10	0	0
Nev:	Las Vegas	<5	<5	7	5	20	25	0	10	0	0
N.H:	Manchester	<5	10	18	15	75	70	0	0	0	0
N.J:	Trenton	<5	<5	12	11	40	30	0	0	0	0
N. Mex:	Albuquerque	<5	<5	6	6	15	15	0	0	0	0
N.Y:	Buffalo	<5	<5	10	11	40	45	0	0	0	0
	New York	<5	<5	13	15	45	45	0	0	0	0
	Syracuse	<5	<5	10	12	40	45	0	0	0	0
N.C:	Charlotte	<5	<5	20	21	30	35	0	30	0	0
N. Dak:	Minot	<5	<5	31	38	45	45	0	0	0	0
Ohio:	Cincinnati	<5	5	12	16	25	30	0	10	0	0
	Cleveland	<5	<5	13	14	35	40	0	0	0	0
Okla:	Oklahoma City	<5	10	13	15	25	25	0	40	0	10
Ore:	Portland	<5	<5	12	13	35	40	0	0	0	0
Pa:	Philadelphia	<5	<5	12	14	35	35	0	0	0	0
	Pittsburgh	<5	<5	17	20	45	50	0	0	0	0
P.R:	San Juan	<5	<5	8	8	25	25	0	20	0	0
R.I:	Providence	<5	10	12	12	45	45	0	0	0	0
S.C:	Charleston	<5	5	23	22	45	50	0	30	0	0
S. Dak:	Rapid City	<5	<5	19	26	45	50	0	0	0	0
Tenn:	Chattanooga	<5	<5	21	21	25	30	0	20	0	0
	Memphis	<5	5	17	20	15	20	0	30	0	0
Tex:	Austin	<5	<5	6	6	15	20	0	10	0	0
	Dallas	<5	10	14	18	20	30	0	30	0	0
Utah:	Salt Lake City	<5	<5	13	13	40	35	0	0	0	0
Vt:	Burlington	<5	<5	14	13	55	55	0	0	0	0
Va:	Norfolk	<5	<5	16	17	25	25	0	0	0	0
Wash:	Seattle	<5	<5	15	19	40	55	0	0	0	0
	Spokane	<5	<5	15	20	40	40	0	0	0	0
W. Va:	Charleston	<5	<5	14	18	25	20	0	10	0	0
Wis:	Milwaukee	<5	5	11	9	40	45	0	0	0	0
Wyo:	Laramie	<5	<5	14	14	30	35	0	0	0	0
Network average		<5	<5	13.8	15.6	35	38	0	11	0	1

[a] Calcium analyses were discontinued as of March 31, 1966.

average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value, except for iodine-131 and barium-140, where zero was used for averaging purposes.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations May 1965 and December 1965–May 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965		1966				
	May	Dec	Jan	Feb	Mar	Apr	May
Under 10	4	9	10	9	9	8	10
10–19	26	43	46	46	44	50	38
20–29	25	11	6	7	7	3	12
30–39	5	0	1	1	3	2	3
40–49	2	0	0	0	0	0	0
50–59	0	0	0	0	0	0	0
60–69	1	0	0	0	0	0	0

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for May 1965 and for December 1965 through May 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, May 1965 and December 1965–May 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965		1966				
	May	Dec	Jan	Feb	Mar	Apr	May
Under 50	17	51	57	56	56	55	51
50–99	31	11	5	6	6	7	11
100–149	13	1	1	1	1	1	1
150–199	2	0	0	0	0	0	0

In anticipation of a significant increase in iodine–131 levels in pasteurized milk, as a result of atmospheric nuclear detonations (*2*), the sampling and analysis frequency for this radionuclide was increased to twice weekly as of May 16. The individual sample results for the second half of May are presented in table 4.

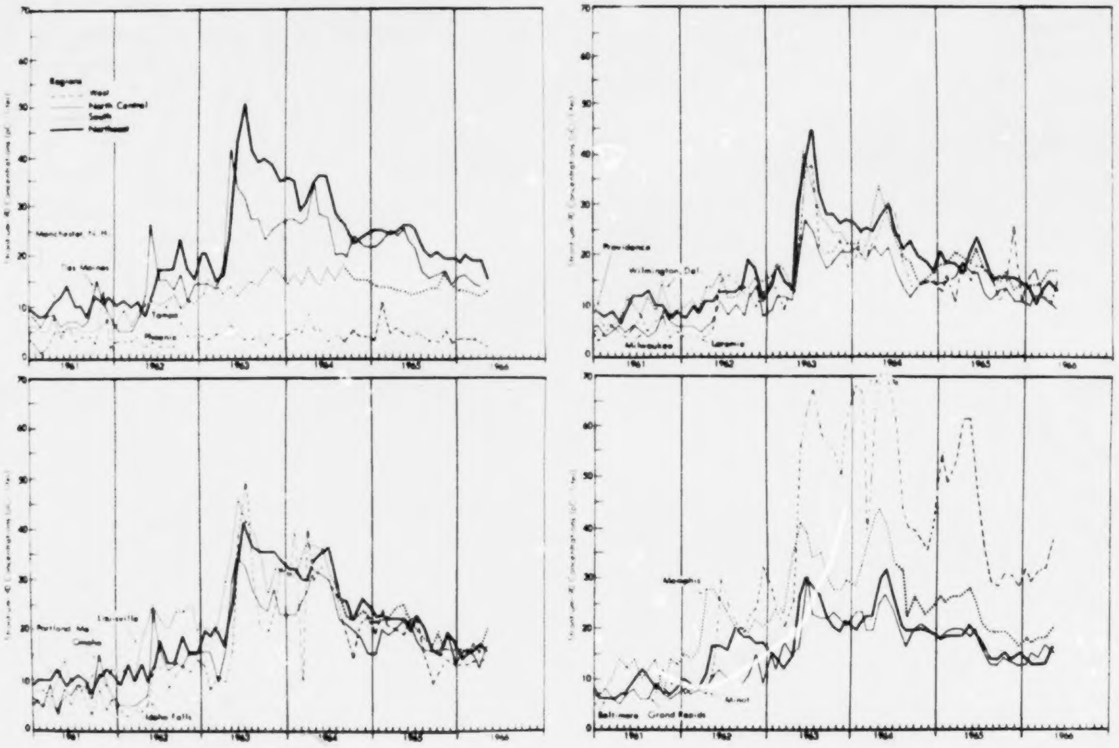

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961—May 1966

Table 4. Daily iodine-131 concentrations in pasteurized milk, May 17–31, 1966

Sampling locations		Daily iodine-131 concentrations, pCi/liter														
		May 1966														
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ala:	Montgomery	<10		<10				50			38					
Alaska:	Palmer	<10			<10				80			<10				
Ariz:	Phoenix	<10			<10				<10			30				
Ark:	Little Rock								392			196				
Calif:	Sacramento	<10			<10				<10			<10				
	San Francisco	<10		<10					<10			<10				
C.Z:	Cristobal							<10								
Colo:	Denver	<10		<10					<10			<10				
Conn:	Hartford	<10			<10				11			<10				
Del:	Wilmington	<10			29							14				
D.C:	Washington	<10		<10					20		17					
Fla:	Tampa	<10			31				31			14				
Ga:	Atlanta	<10		15					36			31				
Hawaii:	Honolulu			<10					<10			<10				
Idaho:	Idaho Falls	<10			<10				<10			<10				
Ill:	Chicago	<10		<10					29		22					
Ind:	Indianapolis	<10			75			132				188				
Iowa:	Des Moines	<10			<10				50			60				
Kans:	Wichita	<10		<10					110			80				
Ky:	Louisville	<10	29						35			39				
La:	New Orleans	<10			<10					34		22				
Maine:	Portland			<10				17			14					
Md:	Baltimore	<10			<10				26			15				
Mass:	Boston	<10			<10				<10			12				
Mich:	Detroit	<10			17				29			35				
	Grand Rapids				<10				16			27				
Minn:	Minneapolis	<10			<10				30			30				
Miss:	Jackson				<10				27			43				
Mo:	Kansas City	<10			80				145			120				
	St. Louis			<10				2			170		180			
Mont:	Helena	<10			<10				<10			<10				
Nebr:	Omaha	<10			<10				<10			60				
Nev:	Las Vegas		<10		<10				<10			20				
N.H:	Manchester	<10		<10					15			<10				
N	Trenton	<10			<10				<10			<10				
N. [illegible]x:	Albuquerque			<10				<10			10					
N.Y:	Buffalo								10			<10				
	New York			<10				<10			<10					
	Syracuse	<10			<10				22			<10				
N.C:	Charlotte			26				65				64				
N. Dak:	Minot			<10				<10			10					
Ohio:	Cincinnati	<10			<10				71			52				
	Cleveland	<10			<10				37			45				
Okla:	Oklahoma City				12				137			118				
Ore:	Portland	<10			<10			<10				10				
Pa:	Philadelphia	<10			<10				15			25				
	Pittsburgh	<10			<10				20			17				
P.R:	San Juan								18			25				
R.I:	Providence	<10			<10				<10			21				
S.C:	Charleston	<10			13				52			103				
S. Dak:	Rapid City	<10			<10				10			30				
Tenn:	Chattanooga	<10			<10				44			37				
	Memphis	<10		13				106			96					
Tex:	Austin				<10				20			48				
	Dallas				13			49			100					
Utah:	Salt Lake City								<10							
Vt:	Burlington	<10		<10					<10			<10				
Va:	Norfolk	<10			<10				18			21				
Wash:	Seattle	<10			<10				<10			20				
	Spokane	<10			<10											
W. Va:	Charleston				<10				33			25				
Wis:	Milwaukee	<10			<10				<10			17				
Wyo:	Laramie	<10			<10				<10			20				

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2. Canadian Milk Network[1]
May 1966

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. The locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*3*).

The May 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5.

During this period, strontium–89 and iodine–131 concentrations were below detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, May 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.5	21.2	71
Edmonton	1.10	1.5	19.2	57
Ft. William	1.13	1.6	29.9	90
Fredericton	1.08	1.6	27.0	71
Halifax	1.16	1.6	22.5	89
Montreal	1.13	1.5	17.0	57
Ottawa	1.17	1.5	12.8	50
Quebec	1.12	1.6	26.9	93
Regina	1.08	1.4	20.0	47
St. John's Nfld	1.13	1.5	22.8	93
Saskatoon	1.13	1.5	19.9	40
Sault Ste. Marie	1.10	1.6	23.2	82
Toronto	1.17	1.5	9.1	45
Vancouver	1.17	1.5	30.4	106
Windsor	1.19	1.6	12.0	62
Winnipeg	1.05	1.6	16.9	61
Average	1.13	1.5	20.7	70

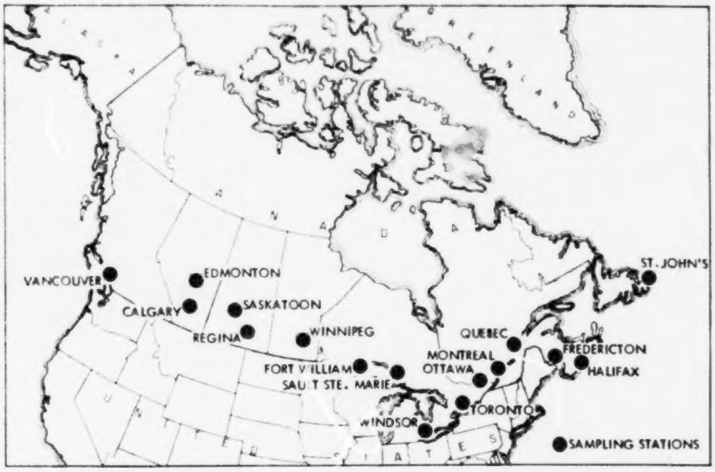

Figure 3. Canadian milk sampling stations

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[1] Prepared from June 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Milk Sampling Program
May 1966

Pan American Health Organization and
U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*4*).

Table 6 presents stable calcium and potassium, strontium-90, strontium-89, and cesium-137 monthly concentrations for May 1966.

Additional data

Data from Caracas, Venezuela, for March and April 1966 was not previously reported in the July and August 1966 issues of *Radiological Health Data and Reports* and have been added to table 6.

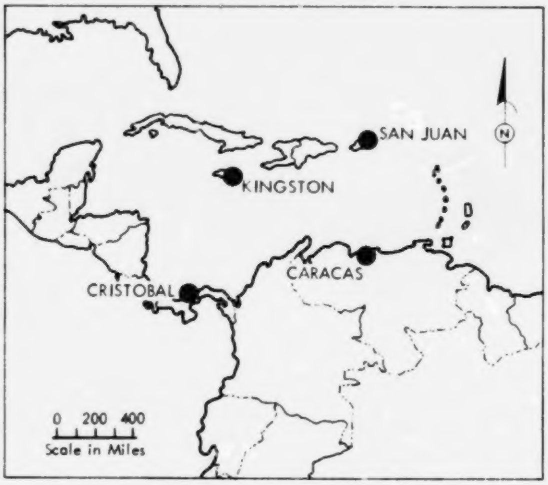

Figure 4. Pan American Milk Network sampling stations

Table 6. Stable element and radionuclide concentrations in PAHO milk, May 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Canal Zone:							
Cristobal	NA	1.5	<5	4	<10	20	<10
Jamaica:							
Kingston	NS	NS	NS	NS	NS	NS	NS
Mandeville	1.09	1.29	20	9	180	140	50
Montego Bay	NS	NS	NS	NS	NS	NS	NS
Puerto Rico:							
San Juan	NA	1.5	<5	8	20	25	<10
Venezuela:							
Caracas							
(March 1966) [a]	1.10	1.44	<5	3	<10	10	<10
(April 1966) [a]	1.10	1.49	<5	4	<10	<10	<10
(May 1966) [a]	1.10	1.60	<5	5	20	30	<10

[a] Data for March and April 1966 not reported in the July and August issues of Radiological Health Data and Reports.
NA, no analysis.
NS, no samples collected.

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(*2*) PUBLIC HEALTH SERVICE. Reported nuclear detonations, May 1966. Rad Health Data Rep 7:376 (June 1966).

(*3*) CANADIAN DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*4*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance programs are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

Milk network	Period reported	Last presented
Colorado	October–December 1964	April 1965
Connecticut	January–March 1966	August 1966
Florida	January–March 1966	July 1966
Indiana	January–March 1966	August 1966
Michigan	October–December and annual summary 1965	May 1966
Minnesota	January–March 1966	August 1966
New York	July–December and annual summary 1965	May 1966
Oklahoma	January–March 1966	July 1966
Pennsylvania	January–March 1966	August 1966
Texas	January–March 1966	July 1966

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1. California Milk Network
January-March 1966

Division of Environmental Sanitation
State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Health program of radiation control. This milk-monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture as representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium-89 and strontium-90 concentrations are determined radiochemically.

Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period January to March 1966.

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 2.

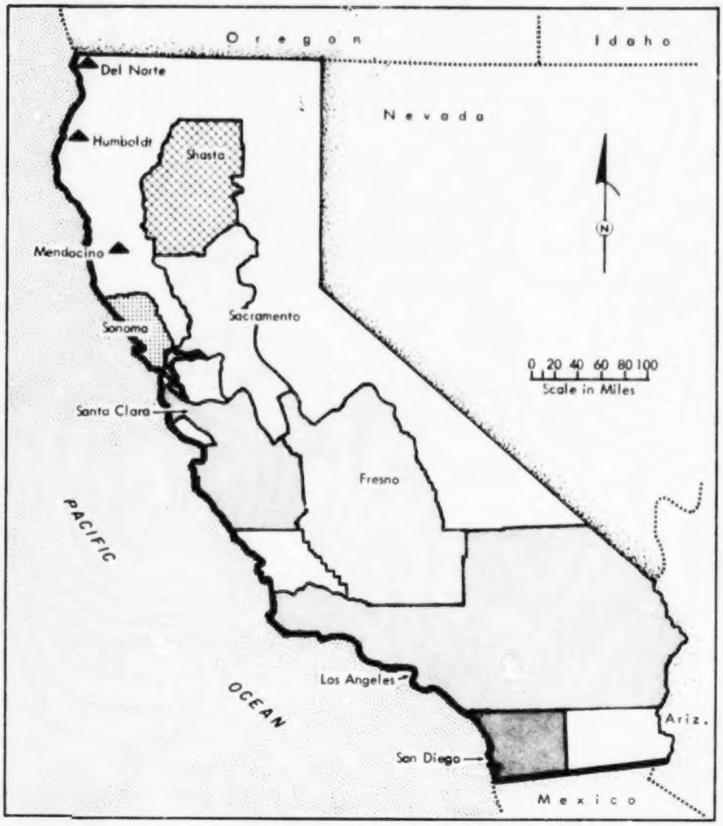
Oregon
Idaho
Del Norte
Nevada
Humboldt
Shasta
N
Mendocino
Sacramento
Sonoma
0 20 40 60 80 100
Scale in Miles
Santa Clara
Fresno
PACIFIC
OCEAN
Los Angeles
Ariz.
San Diego
Mexico

Figure 1. California milksheds

Table 1. Stable elements and radionuclides in California milk, January–March 1966

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium, g/liter											
January	1.39	1.23	1.24	1.09	1.27	1.27	1.14	1.06	1.21	1.24	1.21
February	1.29	1.24	1.18	1.14	1.18	1.22	1.14	1.23	1.20	1.22	1.20
March	1.26	1.20	1.24	1.11	1.16	1.21	1.00	1.19	1.15	1.26	1.18
Potassium-40, pCi/liter											
January	1,110	1,270	1,260	1,240	1,280	1,210	1,400	1,170	1,270	1,270	1,250
February	1,090	1,190	1,190	1,160	1,250	1,200	1,170	1,270	1,200	1,190	1,190
March	1,170	1,250	1,200	1,210	1,210	1,270	1,190	1,360	1,210	1,250	1,230
Strontium-89, pCi/liter											
January	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
February	[a] 3.5	ND	0.9	ND	ND	ND	ND	ND	ND	ND	0.4
March	ND	ND	0.2	0.3	4.0	0.3	ND	ND	ND	0.2	0.5
Strontium-90, pCi/liter											
January	27	5.0	9.2	3.5	7.0	5.0	4.0	3.0	8.0	6.3	7.8
February	21	4.0	7.0	5.0	5.0	5.0	3.0	3.0	7.0	5.3	6.5
March	23	3.4	12.0	3.4	9.0	5.0	3.0	4.0	9.0	7.0	7.9
Cesium-137, pCi/liter											
January	64	21	18	11	18	22	[a] 13	9	23	19	22
February	41	26	21	24	18	22	10	21	32	21	23
March	51	13	31	8	26	31	[a] 6	29	76	30	30

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

ND, below detectable limits.

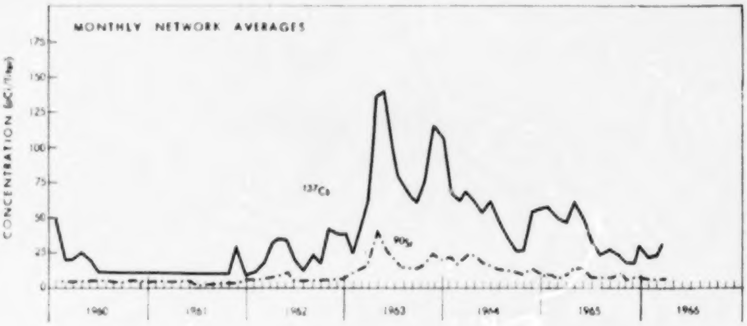

Figure 2. Radionuclide concentrations in California milk January 1960—March 1966

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1963	March 1964
October-December 1963	June 1964
Annual summary 1964	June 1966
Annual summary 1965	June 1966

2. Oregon Milk Network January-March 1966

Division of Sanitation and Engineering Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program, routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or where cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium-90 and cesium-137 concentration in pasteurized milk from January through March 1966. These data are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter.

Table 2. Radionuclide concentrations in Oregon milk, January-March 1966

Sampling location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		Jan	Feb	Mar	Jan	Feb	Mar
Baker	M	10	NA	NA	25	20	30
Coos Bay	M	15	NA	NA	50	50	45
Eugene	M	10	NA	NA	30	25	40
Medford	M	10	NA	NA	25	30	40
Nyssa	M	10	NA	NA	25	35	30
Portland composite	W	15	10	13	40	35	35
Portland local	W	15	NA	NA	45	35	45
Redmond	M	10	NA	NA	50	35	30
Tillamook	M	25	NA	NA	65	60	60
Average	—	15	10	13	40	35	39

M, sampled monthly.
W, sampled weekly.
NA, no analysis.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Summary 1962-1964	June 1965
Annual summary 1965	June 1966

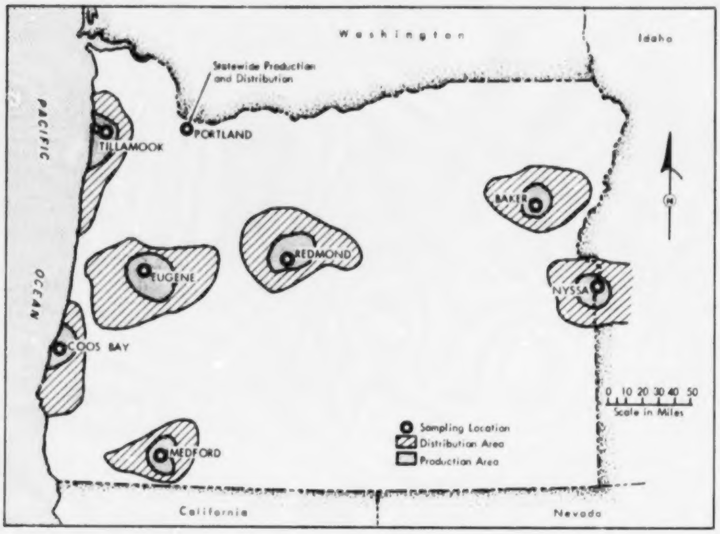
Washington
Idaho
Statewide Production and Distribution
PORTLAND
TILLAMOOK
PACIFIC
OCEAN
BAKER
REDMOND
EUGENE
NYSSA
COOS BAY
MEDFORD
N
0 10 20 30 40 50
Scale in Miles
Sampling Location
Distribution Area
Production Area
California
Nevada

Figure 3. Oregon milk production and distribution areas

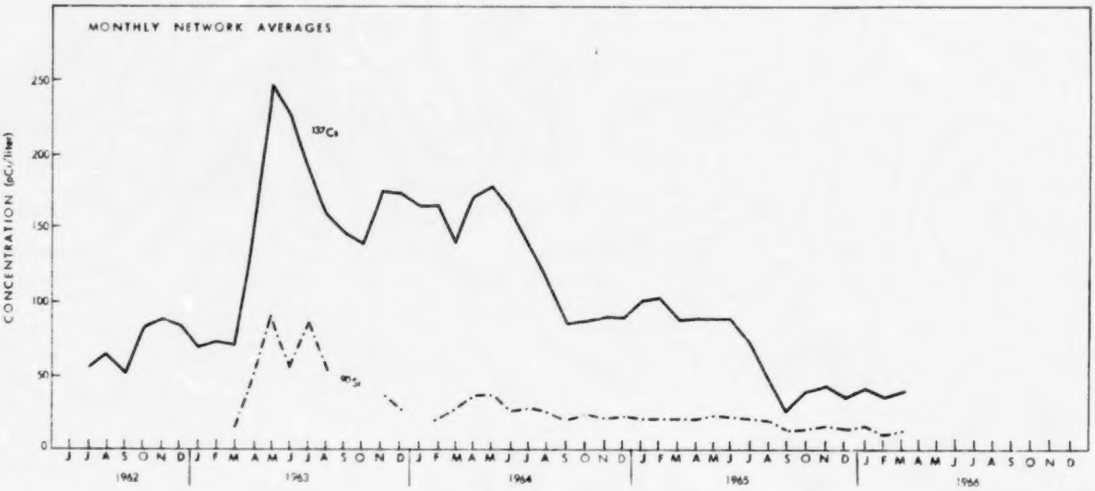

Figure 4. Radionuclide concentrations in Oregon milk network, June 1962—March 1966

3. Washington Milk Network January–March 1966

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The State of Washington Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

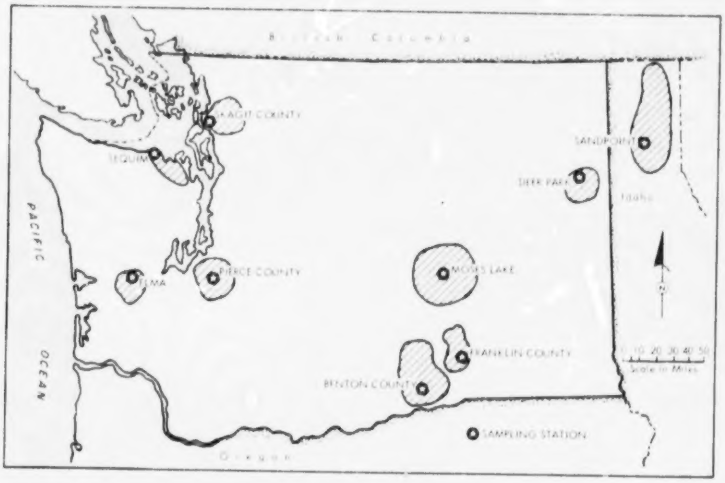

Figure 5. Washington milksheds and sampling locations

Selected samples are analyzed radiochemically for strontium-90. Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for January through March 1966. During this period, iodine-131 and barium-140 concentrations remained below minimum detectable levels. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 6 to display general trends.

Zinc-65 was observed in the Benton-Franklin area on three occasions during this period (table 4). This nuclide has periodically appeared in these areas as a result of the irrigation of some pasture land with Columbia River water which has been shown to contain this contaminant.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
December 1962–December 1963	May 1964
Summary 1964 and 1965	June 1966

Table 3. Radionuclide concentrations in Washington milk, January–March 1966

Sampling location	Potassium-40, pCi/liter		
	January	February	March
Benton County	1,370	1,150	NS
Deer Park	1,240	1,200	1,240
Elma	1,300	1,280	1,290
Franklin County	NS	NS	1,170
Moses Lake	1,270	1,310	1,160
Pierce County	1,270	1,260	1,200
Sandpoint	1,330	1,260	1,090
Sequim	1,300	1,270	1,300
Skagit County	1,270	1,190	1,300
Average	1,309	1,240	1,083
	Strontium-90, pCi/liter		
Benton County	7	7	NS
Deer Park	12	17	11
Elma	9	16	17
Franklin County	NS	NS	5
Moses Lake	7	9	6
Pierce County	10	14	11
Sandpoint	29	37	32
Sequim	14	11	11
Skagit County	8	15	7
Average	12	16	13
	Cesium-137, pCi/liter		
Benton County	23	20	NS
Deer Park	32	39	38
Elma	28	[illegible]	40
Franklin County	NS	NS	34
Moses Lake	25	30	26
Pierce County	43	40	42
Sandpoint	85	90	80
Sequim	40	42	51
Skagit County	30	42	25
Average	38	50	42

NS, no sample collected.

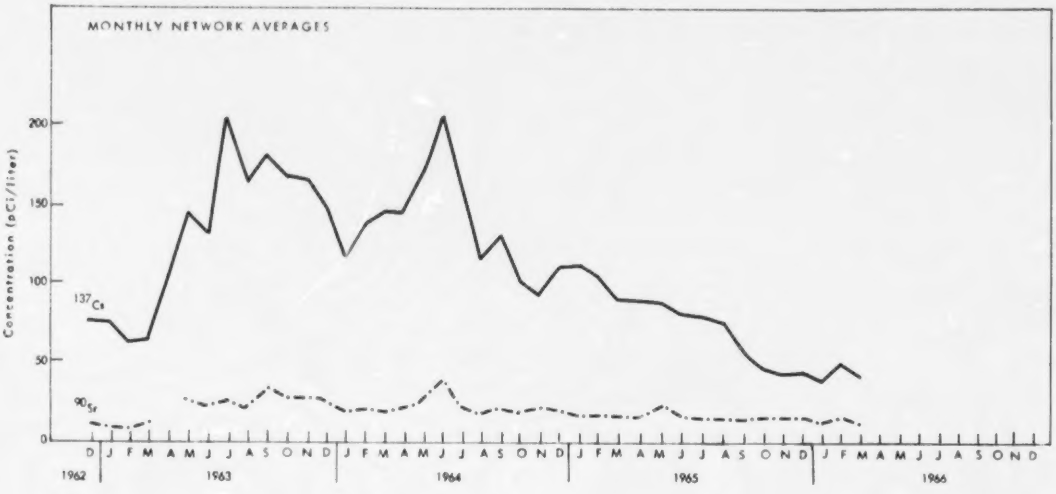

Figure 6. Radionuclide concentrations in Washington milk, 1962—March 1966

Table 4. Milk samples in Washington State containing zinc-65

Sampling location	Collection date, 1966	Zinc-65 (pCi/liter)
Benton County	January 7	104
Benton County	February 7	40
Franklin County	March 7	44

REFERENCES

(*1*) HESLEP, J. M., and A. C. CORNISH. California milk network and milkshed comparisons, April-June 1963. Rad Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960-June 1962. Rad Health Data 4:90–92 (February 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. Rad Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January-June 1965. Rad Health Data: 6:619–621 (November 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically herein include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
Institutional Total Diet PHS	October–December and annual summary 1965	July 1966
Teenage Diet, FDA	February–November 1965	August 1966
Connecticut Standard Diet	January–June 1965	February 1966

1. Strontium-90 in Tri-City Diets November 1965–January 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities every 3 months on a staggered basis (i.e., New York City, November 1965; San Francisco, December 1965; Chicago, January 1966) and are analyzed for strontium-90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium-90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium-90 over the last 4 years has been approximately five percent. Therefore, this figure is used to calculate their contribution to the total strontium-90 dietary intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium-90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for

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[1] Data from Fallout Program Quarterly Summary Report, HASL 172. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

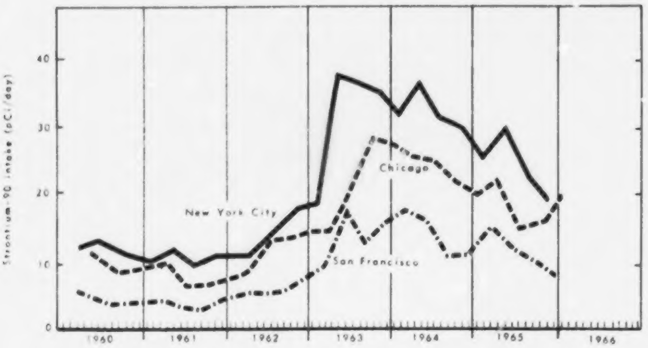

Figure 1. Daily intake of strontium-90 in Tri-City diet 1960—January 1966

the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been previously summarized (*3*).

Results of the November 1965 to January 1966 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1. A discussion of cesium-137 intakes as reflected in the Tri-City Diet Study is presented elsewhere (*4*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Sixteenth sampling (February–April 1964)	December 1964
Seventeenth sampling (July–September 1964)	March 1965
Eighteenth sampling (August–October 1964)	June 1965
Nineteenth sampling (November 1964–January 1965)	September 1965
Twentieth sampling (February–April 1965)	December 1965
Twenty-first sampling (May–July 1965)	March 1966
Twenty-second sampling (August–October 1965)	June 1966

Table 1. Average dietary consumption and strontium-90 intake in Tri-City Diet, November 1965–January 1966

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City November 1965		San Francisco December 1965		Chicago January 1966	
			pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Bakery products	37	37.0	13.4 ±0.9	496	9.0 ±0.9	333	14.6 ±1.0	540
Whole grain products	11	10.0	33.4 ±1.5	367	20.5 ±1.3	225	26.4 ±1.4	290
Fresh vegetables	43	15.0	22.4 ±0.6	963	4.4 ±0.4	189	8.9 ±0.4	383
Root vegetables	17	6.1	11.1 ±0.4	189	14.8 ±0.5	252	10.5 ±0.4	178
Milk	221	234.4	17.6 ±0.2	3,890	4.5 ±0.3	994	16.5 ±0.4	3,646
Flour	43	8.6	13.2 ±0.4	568	3.7 ±0.2	159	18.3 ±0.4	787
Macaroni	3	0.7	9.4 ±0.4	28	11.4 ±0.5	34	12.0 ±0.5	36
Rice	3	1.1	2.6 ±0.2	8	3.4 ±0.3	10	4.4 ±0.3	13
Dried beans	3	2.9	8.0 ±2.0	24	28.1 ±1.7	84	16.7 ±1.4	50
Fresh fruit	68	12.6	7.3 ±3.0	496	3.1 ±0.3	211	3.4 ±0.6	231
Potatoes	45	5.8	8.8 ±0.5	396	3.1 ±0.5	140	7.3 ±0.5	328
Canned fruit	26	1.3	7.8 ±0.2	203	2.3 ±0.1	60	2.2 ±0.1	57
Fruit juices	19	1.7	5.2 ±0.2	99	4.5 ±0.3	86	3.8 ±0.3	72
Canned vegetables	20	4.2	14.1 ±0.5	282	4.8 ±0.4	96	14.3 ±0.6	286
Meat, fish, poultry, shellfish, and eggs	99	42.0		[a] 422		[a] 151		[a] 363
Annual intake, pCi/yr		383		8,131		3,024		7,260
Daily intake, pCi/day		1.05		23.0		8.3		19.9
Strontium-90/calcium, pCi/g				22.0		7.9		19.0

[a] Estimated as 5 percent of total intake.

2. Estimated daily intake of radionuclides in California diets September–December 1965

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (5).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 2).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals, operating with trained dieticians, exist in each of the 20 selected areas. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample

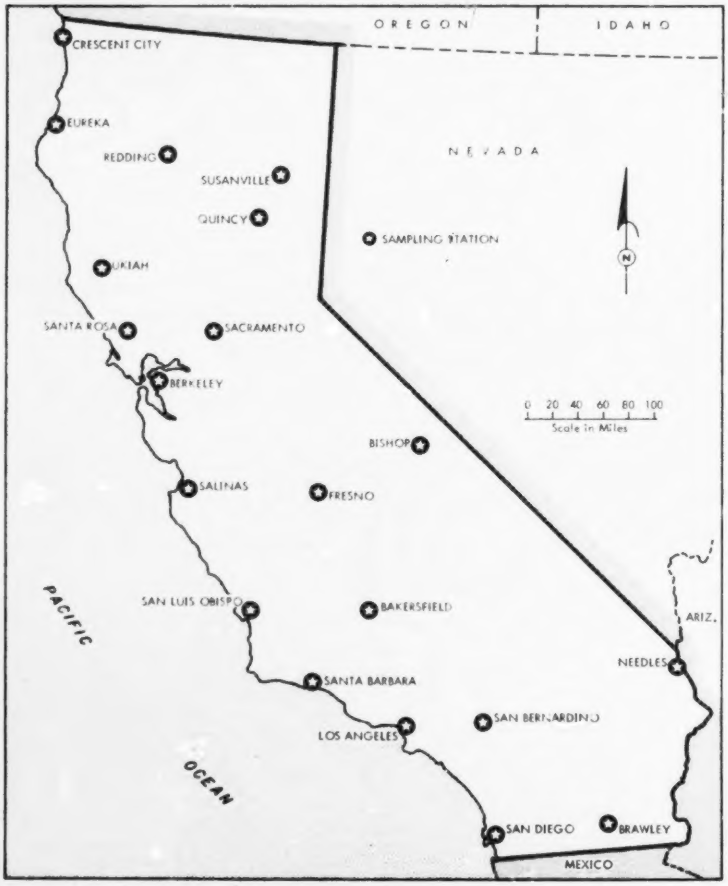
OREGON
IDAHO
CRESCENT CITY
EUREKA
REDDING
SUSANVILLE
QUINCY
NEVADA
SAMPLING STATION
N
UKIAH
SANTA ROSA
SACRAMENTO
BERKELEY
0 20 40 60 80 100
Scale in Miles
BISHOP
SALINAS
FRESNO
PACIFIC
SAN LUIS OBISPO
BAKERSFIELD
ARIZ.
NEEDLES
SANTA BARBARA
SAN BERNARDINO
LOS ANGELES
OCEAN
SAN DIEGO
BRAWLEY
MEXICO

Figure 2. California diet sampling stations

represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized and gamma scanned, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, potassium, strontium, and sodium.

Data and discussion

The resultant estimates of daily intake of

Table 2. Estimated daily intake of radionuclides in California diets, September–October 1965 [a]

City	Consumption (kg/capita•day) [b]	Intake, pCi/capita•day						Intake, g/capita•day			
		Strontium-90	Radium-226	Cesium-137	Zirconium-95	Manganese-54	Cerium-141 cerium-144	Potassium [c]	Sodium	Calcium	Stable strontium
Bakersfield	2.2	8	0.9	38	0	0	12	2.8	4.0	1.1	0.002
Berkeley	2.1	10	0.6	49	5	4	4	2.1	4.0	0.9	<0.001
Bishop	1.6	11	1.2	60	9	0	0	2.2	3.7	0.8	0.001
Brawley	2.0	9	1.2	44	2	0	2	2.5	4.0	0.7	0.003
Crescent City	2.4	19	0.4	(d)	(d)	(d)	(d)	3.1	5.3	1.1	0.001
Eureka	2.0	24	0.2	82	7	0	0	2.6	2.3	1.6	0.001
Fresno	2.1	14	0.3	106	18	3	0	2.2	3.5	0.9	0.002
Los Angeles	2.6	7	0.5	(d)	(d)	(d)	(d)	2.5	3.4	0.8	0.002
Needles	1.6	8	0.5	39	7	0	0	1.9	2.7	0.7	0.001
Quincy	1.2	4	0.5	37	4	0	0	3.6	2.0	0.4	<0.001
Redding	1.7	7	0.4	50	3	0	0	2.2	3.7	0.6	<0.001
Sacramento	2.5	13	0.8	56	9	0	18	2.8	5.2	1.1	0.001
Salinas	2.4	6	0.3	57	0	0	0	3.0	4.4	0.9	0.002
San Bernardino	2.0	9	0.4	44	4	0	0	2.6	3.7	1.2	0.003
San Diego	1.7	6	0.8	48	3	0	0	2.2	1.9	0.6	0.001
San Luis Obispo	1.1	6	0.6	17	3	4	11	2.0	3.1	0.6	0.001
Santa Barbara	2.1	6	0.3	67	2	0	0	2.6	4.0	0.9	0.002
Santa Rosa	2.3	12	0.8	54	7	0	0	2.2	3.3	1.0	0.001
Susanville	2.0	8	0.4	51	4	0	0	2.3	4.7	0.7	0.002
Ukiah	2.1	12	<0.1	40	2	0	0	2.0	2.4	1.7	0.001

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Sample lost.

Table 3. Estimated daily intake of radionuclides in California diets, November–December 1965 [a]

City	Consumption (kg/capita•day) [b]	Intake, pCi/capita•day						Intake, g/capita•day			
		Strontium-90	Radium-226	Cesium-137	Zirconium-95	Manganese-54	Cerium-141 cerium-144	Potassium [c]	Sodium	Calcium	Stable strontium
Bakersfield	2.2	7	0.3	27	4	0	2	2.4	3.5	1.0	<0.001
Berkeley	2.0	10	0.7	42	1	0	0	2.2	3.7	0.9	0.002
Bishop	1.9	32	1.7	55	7	0	3	2.6	3.7	2.0	0.001
Brawley	2.0	9	0.8	32	6	0	4	2.2	3.7	1.0	0.002
Crescent City	2.3	16	0.5	67	11	0	4	2.8	5.0	1.5	0.001
Eureka	2.2	16	0.7	58	4	0	7	2.5	3.7	1.2	0.001
Fresno	2.3	37	0.6	56	5	1	0	2.4	4.0	1.5	0.003
Los Angeles	3.0	11	0.8	49	10	0	2	2.9	4.0	0.8	0.003
Needles	1.8	12	0.2	42	8	0	0	2.4	2.3	1.0	0.001
Quincy	1.3	8	0.3	40	6	0	0	1.5	2.0	0.5	0.001
Redding	2.0	11	0.9	44	7	0	5	2.8	4.9	1.0	0.002
Sacramento	2.8	18	1.8	71	1	0	0	3.4	5.7	1.5	0.002
Salinas	2.4	10	0.9	48	3	0	5	2.8	4.6	0.8	0.001
San Bernardino	2.0	18	0.9	71	1	0	12	2.7	4.0	1.0	0.001
San Diego	2.0	8	0.5	27	5	0	1	2.4	2.5	0.8	0.001
San Luis Obispo	1.4	9	0.5	45	6	0	0	2.0	3.0	0.7	0.001
Santa Barbara	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)
Santa Rosa	2.5	11	0.4	55	8	0	5	2.8	3.2	1.4	0.001
Susanville	2.0	8	0.2	48	7	0	0	2.3	3.7	0.7	0.001
Ukiah	2.4	10	1.1	52	11	0	0	2.9	3.3	1.5	0.003

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Sample lost.

radionuclides in the California diets are given in table 2 (September–October 1965) and table 3 (November–December 1965).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. Average strontium-90 intake in the California diet for the September–October 1965 period varied from 4 to 24 pCi/capita • day with an average of 10 pCi/capita • day. Cesium-137 intakes varied from 17 to 106 pCi/capita • day with an average of 52 pCi/capita • day. For the November–December 1965 sampling period, the strontium-90 intake

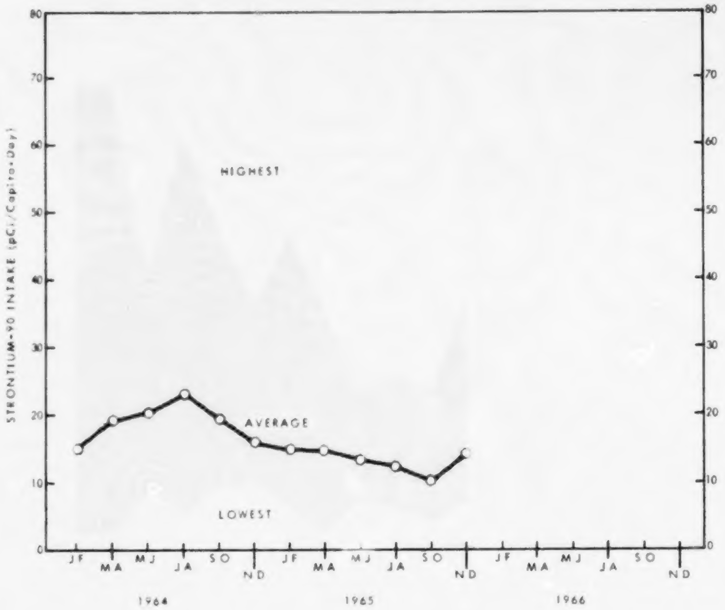

Figure 3. Averages and ranges of daily strontium-90 intake in California diets

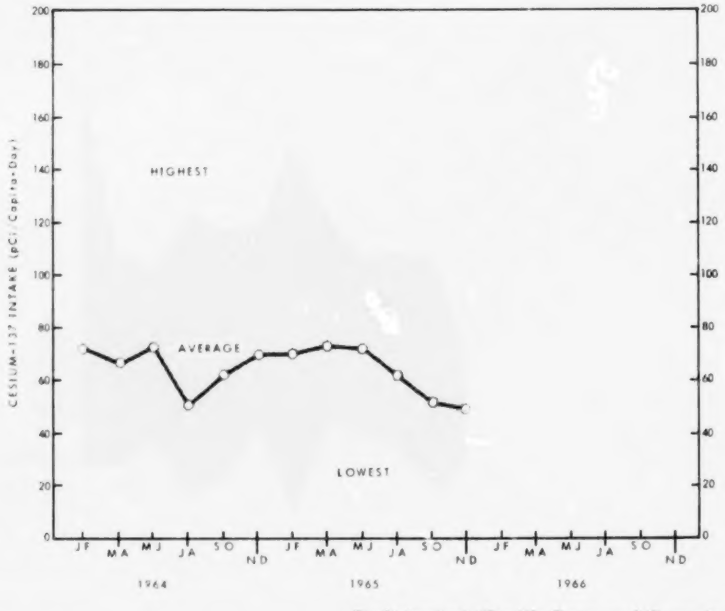

Figure 4. Averages and ranges of daily cesium-137 intake in California diets

varied from 7 to 37 pCi/capita • day with an average of 14 pCi/capita • day. Cesium-137 intakes varied from 27 to 71 pCi/capita • day with an average of 49 pCi/capita • day. A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through December 1965 is given in figures 3 and 4.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
January-June 1964	March and April 1965
July-October 1964	September 1965
November-December 1964	December 1965
January-April 1965	March 1966
May-August 1965	June 1966

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report, HASL-144:281-287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964). Summarized in Rad Health Data 5:285-288 (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL-147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*4*) RIVERA, J. Dietary intakes and body burdens of cesium-137. Rad Health Data 6:504-506 (September 1965).

(*5*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Rad. Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley 4, California.

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross alpha and gross beta radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guidelines recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Pub 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards. Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards. Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MARCH 1966

Basic Data Program
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The figures for gross alpha and gross beta radioactivity represent either determinations on composites or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and

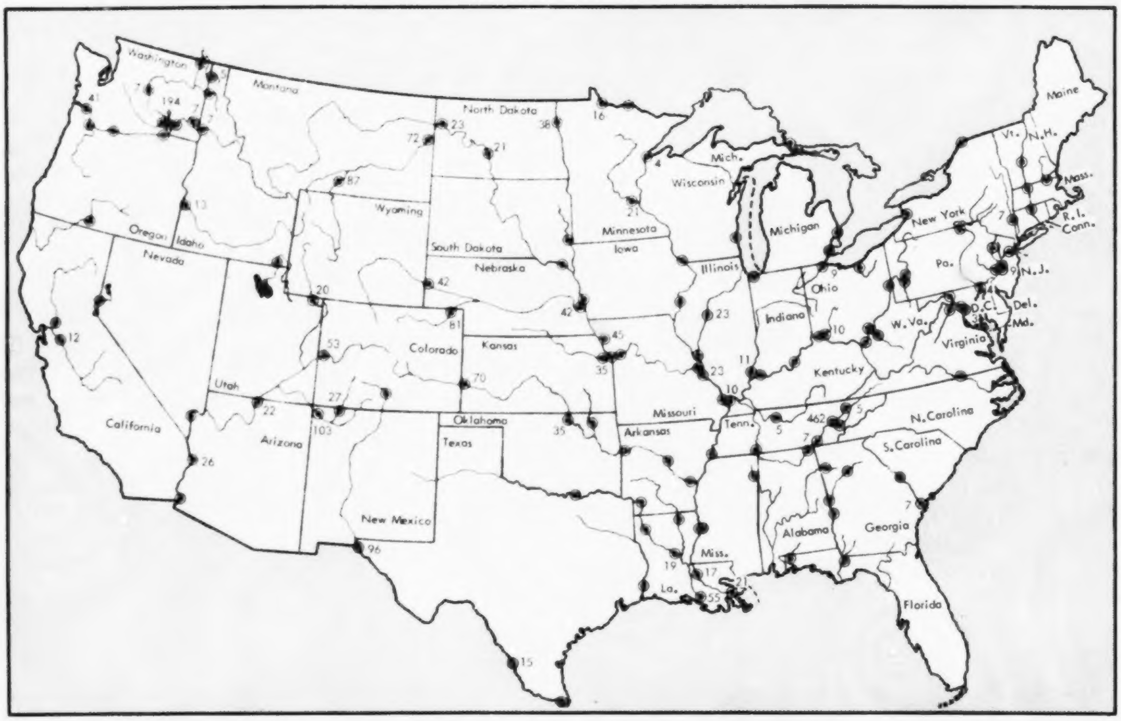
Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Indiana
Ohio
W. Va.
Virginia
Nevada
Utah
Colorado
Kansas
Missouri
Kentucky
California
Arizona
New Mexico
Oklahoma
Texas
Arkansas
Tenn.
N. Carolina
S. Carolina
Miss.
Alabama
Georgia
La.
Florida
41
7
194
7
7
5
23
72
21
38
16
87
13
4
21
42
20
42
81
53
70
45
35
23
23
11
10
9
10
12
22
27
103
26
35
5
462
5
7
7
9
4
3
96
19
17
21
55
15
7

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface water, March 1966

analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations are published in annual compilations (*1-6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February and March, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River: Henry, Nebraska
Arkansas River: Ponca City, Oklahoma
Arkansas River: Coolidge, Kansas

Julesburg, Colorado, on the South Platte River showed an alpha radioactivity value in excess of 15 pCi/liter on dissolved solids.

Table 1. Radioactivity in raw surface waters, March 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	18	9	27	3	2	5
Arkansas River:						
Coolidge, Kans	2	68	70	<1	41	41
Ponca City, Okla	14	21	35	3	13	16
Atchafalaya River:						
Morgan City, La	47	8	55	12	1	13
Big Horn River:						
Hardin, Mont	72	15	87	35	4	39
Chena River:						
Fairbanks, Alaska	<1	3	3	0	<1	<1
Clearwater River:						
Lewiston, Idaho	4	3	7	<1	0	<1
Clinch River:						
Clinton, Tenn	0	5	5	0	0	0
Kingston, Tenn *	8	454	462	0	2	2
Colorado River:						
Loma, Colo	34	19	53	9	5	14
Page, Ariz	1	21	22	0	5	5
Parker Dam, Calif-Ariz	2	24	26	0	5	5
Columbia River:						
Wenatchee, Wash	1	6	7	0	1	1
Pasco, Wash *	30	164	194	0	<1	<1
Clatskanie, Ore	7	34	41	0	<1	<1
Cumberland River:						
Cheatham Lock, Tenn	1	4	5	0	0	0
Delaware River:						
Philadelphia, Pa	3	6	9	0	0	0
Green River:						
Dutch John, Utah	1	19	20	0	2	2
Hudson River:						
Poughkeepsie, N. Y	1	6	7	0	0	0
Illinois River:						
Peoria, Ill	12	11	23	3	1	4
Kansas River:						
DeSoto, Kans	12	23	35	3	5	8
Little Miami River:						
Cincinnati, Ohio	1	9	10	0	1	1
Maumee River:						
Toledo, Ohio	0	9	9	0	1	1
Mississippi River:						
St. Paul, Minn	2	19	21	0	1	1
E. St. Louis, Ill	12	11	23	2	1	3
New Roads, La	7	10	17	1	0	1
New Orleans, La	12	9	21	4	0	4
Missouri River:						
Williston, N. Dak	3	20	23	1	2	3
Bismarck, N. Dak	4	17	21	1	2	3
St. Joseph, Mo	25	20	45	9	3	12
North Platte River:						
Henry, Nebr	2	40	42	<1	28	28
Ohio River:						
Cairo, Ill	3	7	10	1	0	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	4	5	0	<1	<1
Platte River:						
Plattsmouth, Nebr	18	24	42	5	7	12
Potomac River:						
Washington, D. C	0	3	3	1	0	1
Rainy River:						
Baudette, Minn	5	11	16	<1	0	<1
Red River, North:						
Grand Forks, N. Dak	7	31	38	1	2	3
Red River, South:						
Alexandria, La	7	12	19	2	0	2
Rio Grande:						
Alamosa, Colo	82	14	96	27	4	31
El Paso, Tex	3	12	15	<1	3	3
San Joaquin River:						
Vernalis, Calif	2	10	12	0	2	2
San Juan River:						
Shiprock, N. Mex	91	12	103	34	2	36
Savannah River:						
Port Wentworth, Ga *	1	6	7	0	0	0
Snake River:						
Payette, Idaho	2	11	13	0	3	3
Wawawai, Wash	1	6	7	0	2	2
South Platte River:						
Julesburg, Colo	9	72	81	2	38	40
Susquehanna River:						
Conowingo, Md	1	3	4	0	0	0
Tennessee River:						
Chattanooga, Tenn	1	6	7	0	0	0
Wabash River:						
New Harmony, Ind	3	8	11	<1	1	1
Yellowstone River:						
Sidney, Mont	52	20	72	12	3	15
Maximum	91	454	462	35	41	41
Minimum	0	3	3	0	0	0

* Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

During March, the following stations showed a beta radioactivity in excess of 150 pCi/liter on dissolved solids:

Columbia River: Pasco, Washington
Clinch River: Kingston, Tennessee

Since the value reported for Kingston, Tennessee, is somewhat unusual when compared with data for the previous 12 months, special attention has been directed to this station. Further determinations of specific radionuclides are being carried out.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity resulting from intrusions into the atmosphere. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

Program	Period reported	Last presented
National Air Sampling Network	January–March 1966	July 1966

1. Radiation Surveillance Network
May 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during May 1966. Time profiles of gross beta in air, dating back to 1958, for eight RSN stations are shown in figure 2.

Fresh fission products, presumably from the Chinese nuclear test of May 9, 1966, were detected in network samples collected during May. The first appearance of fresh fission

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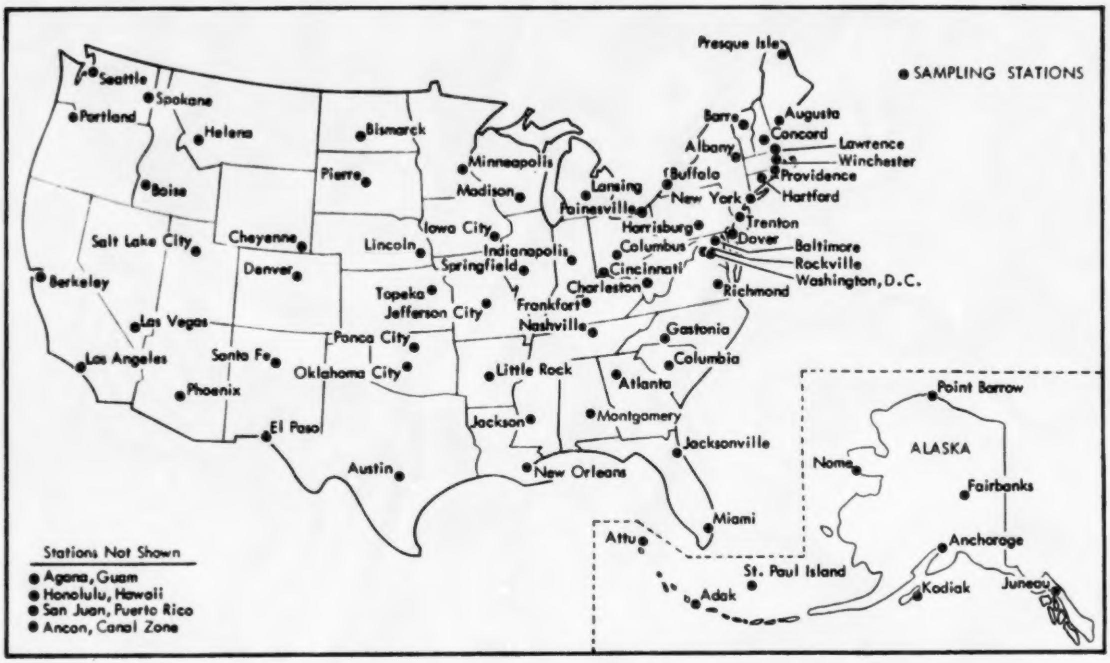
SAMPLING STATIONS
Presque Isle
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Lansing
Painesville
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Dover
Harrisburg
Baltimore
Rockville
Washington, D.C.
Columbus
Cincinnati
Charleston
Richmond
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Denver
Topeka
Jefferson City
Frankfort
Nashville
Gastonia
Columbia
Berkeley
Las Vegas
Ponca City
Santa Fe
Oklahoma City
Little Rock
Atlanta
Los Angeles
Phoenix
El Paso
Jackson
Montgomery
Jacksonville
Austin
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

products was at Boise, Idaho, on May 14. This sample contained a gross beta activity of 2.39 pCi/m^3 at the time of collection. The highest air activity was observed at Phoenix, Arizona, on May 20. Extrapolated to time of collection, the activity was 14.87 pCi/m^3, with an estimated age of 12 days.

Gross beta activity in precipitation samples also increased sharply during the latter half of May. The greatest depositions of radionuclides by precipitation were observed in the midwest:

Date May 1966	Location	Precipitation (mm)	Concentration (pCi/liter)	Deposition (pCi/m^2)
18	Indianapolis, Ind	1.8	56.0	102
18	Springfield, Ill	22.5	9.7	219
23	Minneapolis, Minn	4.3	10.4	44
17	Jefferson City, Mo	2.0	124.9	250
18	Jefferson City, Mo	21.5	9.5	204
21	Jefferson City, Mo	19.0	1.0	19
24	Jefferson City, Mo	18.4	4.8	89
20	Lincoln, Neb	10.0	3.4	34
23	Lincoln, Neb	56.3	1.0	57

However, high depositions were observed in other parts of the country such as Augusta, Maine, and various cities in the South.

Table 1. Gross beta activity in surface air and precipitation, May 1966

Station location		Number of samples		Air surveillance			Last profile in *RHD&R*	Precipitation	
				Gross beta activity, pCi/m³				Total depth (mm)	Total deposition (nCi/m²)
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	10	2.40	<0.10	<0.51	Feb 66	88	<25
Alaska:	Adak	31		0.35	<0.10	<0.11	Jun 66	(b)	
	Anchorage	25	5	0.16	<0.10	<0.11	Mar 66	13	<3
	Attu Islands	11		0.44	<0.10	<0.13	Jul 66	(b)	
	Fairbanks	(c)					Apr 66	(b)	
	Juneau	27	24	<0.10	<0.10	<0.10	Jul 65	263	<53
	Kodiak	6		<0.10	<0.10	<0.10	May 66	(b)	
	Nome	19		<0.10	<0.10	<0.10	Sep 66	(b)	
	Pt. Barrow	31		<0.10	<0.10	<0.10	Aug 66	(b)	
	St. Paul Island	31		<0.10	<0.10	<0.10	Jan 66	(b)	
Ariz:	Phoenix	29		14.87	<0.10	<2.63	Jul 65	(b)	
Ark:	Little Rock	20	2	1.73	<0.10	<0.42	Mar 66	28	<6
Calif:	Berkeley	28	1	0.59	<0.10	<0.13	May 66	3	<1
	Los Angeles	28	1	2.30	<0.10	<0.47	Sep 66	7	<1
C.Z:	Ancon	23		0.98	<0.10	<0.17	May 66	(b)	
Colo:	Denver	28	2	14.29	<0.10	<1.35	May 66	8	<2
Conn:	Hartford	31	11	0.69	<0.10	<0.20	Apr 66	82	<21
Del:	Dover	26		1.83	<0.10	<0.26	Feb 66	(b)	
D.C:	Washington	30	9	1.42	<0.10	<0.26	Aug 66	90	<35
Fla:	Jacksonville	31	21	2.03	<0.10	<0.55	Mar 66	352	<253
	Miami	29	8	2.95	<0.10	<0.86	Apr 66	163	<51
Ga:	Atlanta	(c)					Jan 66	(b)	
Guam:	Agana	31		<0.10	<0.10	<0.10	Feb 66	(b)	
Hawaii:	Honolulu	31	1	2.85	<0.10	<0.46	Jul 66	20	<4
Idaho:	Boise	31	1	4.91	<0.10	<0.65	Jul 66	1	<1
Ill:	Springfield	30	5	2.75	<0.10	<0.35	Aug 66	110	<270
Ind:	Indianapolis	31	7	3.40	<0.10	<0.35	Jan 66	37	<115
Iowa:	Iowa City	30	8	0.45	<0.10	<0.15	May 66	143	<37
Kans:	Topeka	31	4	8.95	<0.10	<0.53	Mar 66	24	<12
Ky:	Frankfort	29	7	1.81	<0.10	<0.20	Aug 66	48	<59
La:	New Orleans	31	10	2.33	<0.10	<0.39	Aug 66	206	<63
Maine:	Augusta	31	10	0.59	<0.10	<0.18	Sep 66	85	<96
	Presque Isle	24	6	0.61	<0.10	<0.15	May 66	74	<15
Md:	Baltimore	28	10	1.48	<0.10	<0.23	Apr 66	74	<22
	Rockville	27		1.88	<0.10	<0.27	Jul 66	(b)	
Mass:	Lawrence	31	11	0.75	<0.10	<0.20	Feb 66	87	<21
	Winchester	29	10	1.28	<0.10	<0.19	Jun 66	93	<19
Mich:	Lansing	31	7	0.57	<0.10	<0.15	Jul 66	50	<21
Minn:	Minneapolis	28	11	0.92	<0.10	<0.17	Feb 66	47	<67
Miss:	Jackson	29	7	3.19	<0.10	<0.60	Sep 66	187	<75
Mo:	Jefferson City	31	9	5.92	<0.10	<0.53	Jan 66	111	<576
Mont:	Helena	30	4	8.97	<0.10	<0.75	Jun 66	15	<4
Nebr:	Lincoln	26	6	3.68	<0.10	<0.31	Jan 66	88	<99
Nev:	Las Vegas	28		6.38	<0.10	<1.74	Apr 66	(b)	
N.H:	Concord	28		0.79	<0.10	<0.18	Aug 66	(b)	
N.J:	Trenton	31	8	1.25	<0.10	<0.23	Sep 66	33	<8
N.Mex:	Santa Fe	30	1	9.94	<0.10	<1.94	Jun 66	4	<1
N.Y:	Albany	24	9	0.30	<0.10	<0.15	Jan 66	68	<16
	Buffalo	31		0.39	<0.10	<0.13	May 66	(b)	
	New York	27		0.56	<0.10	<0.17	Jun 66	(b)	
N.C:	Gastonia	31	9	1.64	<0.10	<0.40	May 66	81	<106
N.Dak:	Bismarck	29	5	3.06	<0.10	<0.24	Aug 66	26	<6
Ohio:	Cincinnati	20		1.53	<0.10	<0.18	Feb 66	(b)	
	Columbus	31	9	2.61	<0.10	<0.34	Sep 66	89	<34
	Painesville	30	5	1.09	<0.10	<0.17	Apr 66	49	<13
Okla:	Oklahoma City	30	3	5.62	<0.10	<0.61	Jul 66	10	<52
	Ponca City	28	4	1.47	<0.10	<0.27	Apr 66	56	<21
Ore:	Portland	26	7	12.17	<0.10	<0.64	Jan 66	16	<3
Pa:	Harrisburg	29	1	0.80	<0.10	<0.19	Jan 66	5	1
P.R:	San Juan	29	3	3.07	<0.10	<0.44	Sep 66	146	<23
R.I:	Providence	28	10	0.87	<0.10	<0.19	Jul 66	103	<22
S.C:	Columbia	28	10	1.93	<0.10	<0.39	Jun 66	116	<32
S.Dak:	Pierre	31	3	4.01	<0.10	<0.40	Jun 66	25	<5
Tenn:	Nashville	31	7	2.52	<0.10	<0.40	Jul 66	76	<86
Tex:	Austin	30	10	0.83	<0.10	<0.28	Feb 66	85	<23
	El Paso	31		6.06	<0.10	<0.95	Aug 66	(b)	
Utah:	Salt Lake City	30	2	9.72	<0.10	1.05	Sep 66	17	<4
Vt:	Barre	31	12	0.83	<0.10	<0.18	Mar 66	61	<13
Va:	Richmond	31	8	1.68	<0.10	<0.34	Mar 66	68	<14
Wash:	Seattle	31	8	<0.10	<0.10	<0.10	Mar 66	26	<5
	Spokane	31	3	6.03	<0.10	<0.47	Feb 66	15	<8
W.Va:	Charleston	30	7	0.69	<0.10	<0.21	Jun 66	53	<14
Wis:	Madison	28	5	1.39	<0.10	<0.17	Mar 66	71	<42
Wyo:	Cheyenne	31	2	7.82	<0.10	<0.80	Apr 66	3	<2
Network summary		2,039	379	14.87	<0.10	<0.41		70	<47

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[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.

[b] Indicates no report received.

[c] Indicates no precipitation sample collected.

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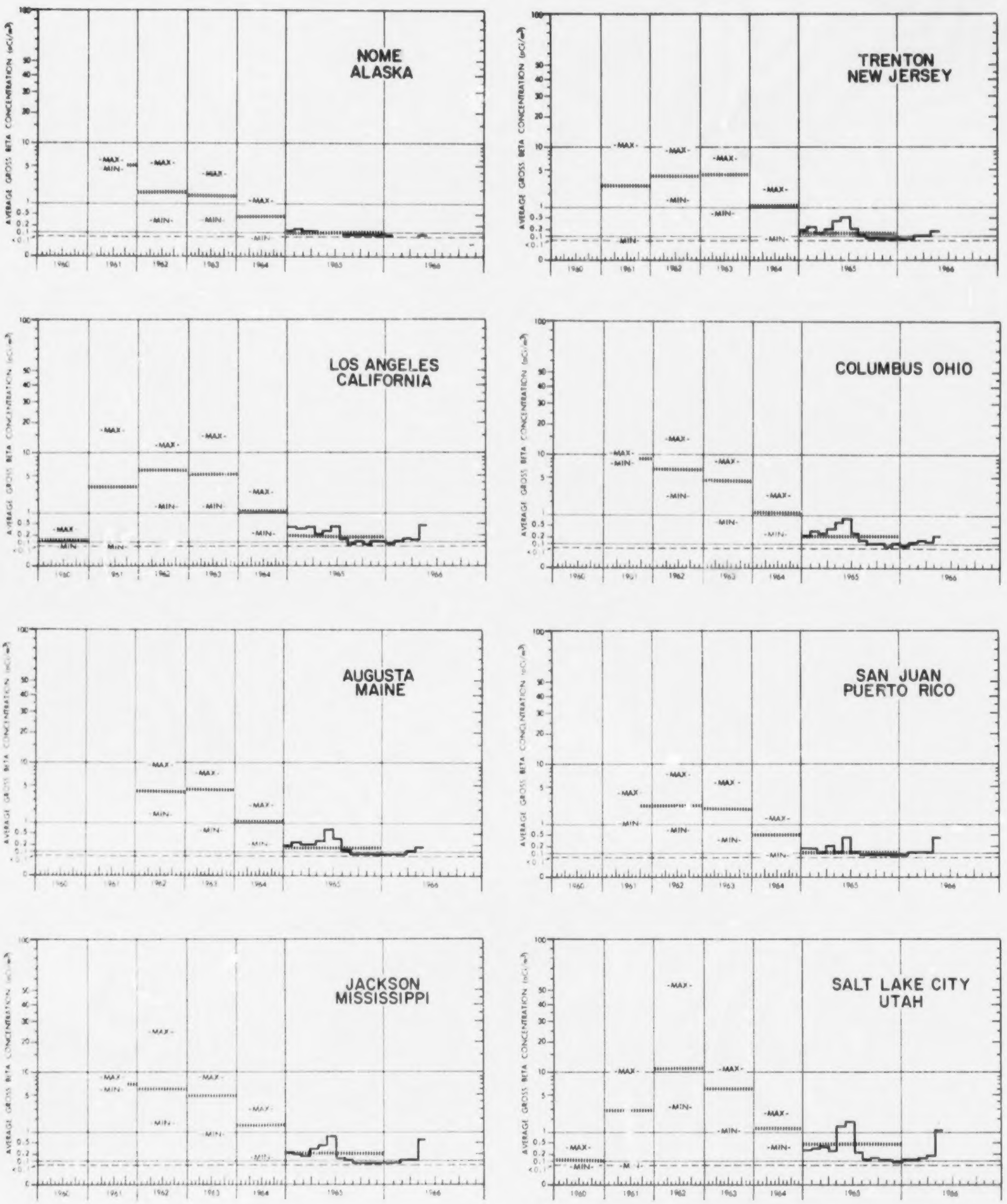

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960—May 1966

2. Canadian Air and Precipitation Monitoring Program, May 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data*.

Surface air and precipitation data for May 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, May 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	2.2	0.0	0.4	194	16.0
Coral Harbour	30	0.2	0.0	0.1	118	4.0
Edmonton	31	2.6	0.0	0.2	143	4.6
Ft. Churchill	31	0.2	0.0	0.1	107	3.0
Ft. William	31	1.3	0.0	0.1	158	6.8
Fredericton	31	1.0	0.0	0.2	117	6.8
Goose Bay	31	0.2	0.0	0.0	38	3.5
Halifax	31	0.5	0.0	0.2	232	11.9
Inuvik	31	0.1	0.0	0.1	34	1.0
Montreal	31	0.4	0.1	0.2	60	2.3
Moosonee	31	0.3	0.0	0.1	72	3.9
Ottawa	30	2.7	0.0	0.3	115	6.9
Quebec	31	0.6	0.0	0.2	NS	NS
Regina	31	1.4	0.1	0.2	563	14.0
Resolute	31	0.2	0.0	0.1	NS	NS
St. John's Nfld	30	0.2	0.0	0.1	76	8.0
Saskatoon	31	0.4	0.0	0.1	249	3.7
Saulte Ste. Marie	31	0.3	0.0	0.1	54	3.3
Toronto	31	1.5	0.0	0.2	229	11.0
Vancouver	31	7.8	0.0	0.3	59	2.2
Whitehorse	31	0.2	0.0	0.1	122	0.7
Windsor	18	2.6	0.0	0.4	296	15.7
Winnipeg	31	5.5	0.0	0.3	1 473	56.1
Yellowknife	31	0.4	0.0	0.1	143	2.4
Network summary		1.4	0.0	0.2	225	8.5

NS, no sample collected.

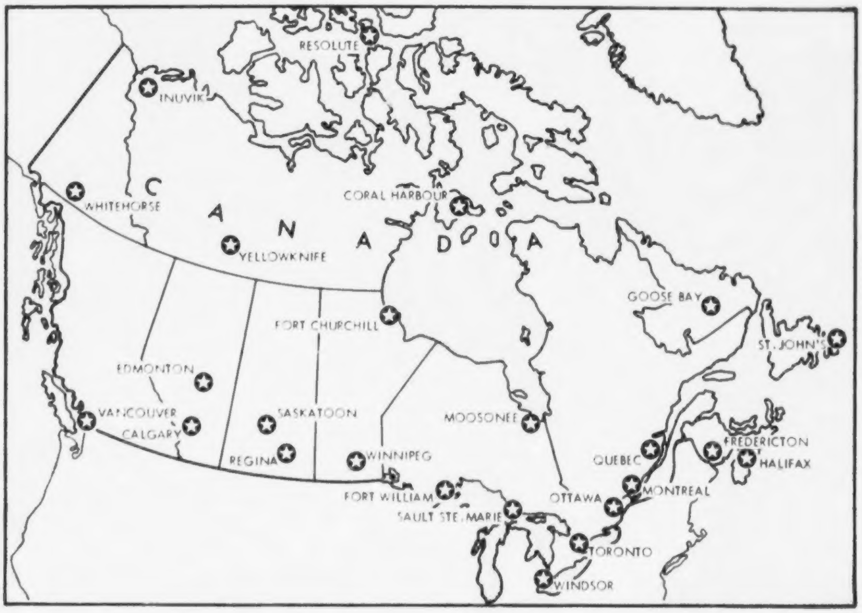
RESOLUTE
INUVIK
C
A
N
A
D
A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the June 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Mexican Air Monitoring Program January and February 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México City. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8-12*).

In 1961, the CNEN appointed its Division of Radiological Security (DRS) to establish a new Radiation Surveillance Network. This network consists of 17 stations (figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at México City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

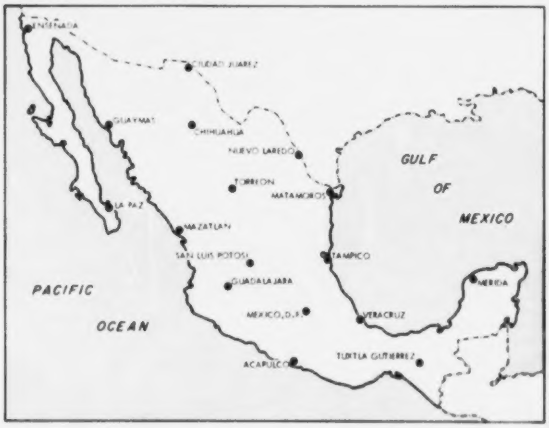

Figure 4. Mexican air sampling station locations

Details of sampling procedures were presented in the December 1965 issue of *Radiological Health Data.* Samples are counted a minimum of 3 days after collection to allow for decay of radon and thoron. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission product beta activity concentrations in surface air during January and February 1966 are presented in tables 3 and 4, respectively.

Table 3. Mexican gross beta activity of airborne particulates, January 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	NS			
Ciudad Juárez	18	0.9	0.3	0.6
Chihuahua	17	1.1	0.4	0.7
Ensenada	11	0.8	0.1	0.4
Guadalajara	2	0.3	0.1	
Guaymas	21	0.5	0.2	0.4
La Paz	13	0.4	0.1	0.2
Matamoros	9	1.0	0.1	0.3
Mazatlán	12	0.3	0.2	0.2
Mérida	11	0.2	0.1	0.1
Mexico, D.F	14	1.2	0.1	0.3
Nuevo Laredo	3	0.2	0.2	0.2
San Luis Potosi	15	0.6	0.1	0.2
Tampico	4	0.1	0.1	0.1
Terréon	12	0.3	0.1	0.2
Tuxtla Gutierrez	NS			
Veracruz	20	0.5	0.1	0.2

NS, no sample collected, station temporarily shut down.

Table 4. Mexican gross beta activity of airborne particulates, February 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	4	0.4	0.3	0.3
Ciudad Juárez	20	1.0	0.4	0.7
Chihuahua	8	1.0	0.3	0.6
Ensenada	NS			
Guadalajara	10	0.7	0.1	0.3
Guaymas	5	0.6	0.1	0.5
La Paz	15	0.4	0.1	0.2
Matamoros	NS			
Mazatlán	11	0.3	0.2	0.3
Mérida	8	0.3	0.1	0.2
Mexico, D.F	20	0.4	0.1	0.2
Nuevo Laredo	1	0.1	<0.1	<0.1
San Luis Potosí	1	0.1	<0.1	<0.1
Tampico	5	0.4	0.1	0.1
Terréon	18	0.4	0.1	0.2
Tuxtla Gutierrez	NS			
Veracruz	15	0.3	0.1	0.2

NS, no sample collected, station temporarily shut down.

4. Pan American Air Sampling Program May 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed by the Radiation Surveillance Network. The air sampling positions are shown in figure 5.

The May 1966 air monitoring results from the participating countries are given in table 5.

Table 5. PAHO gross beta activity in surface air, May 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	15	<0.10	<0.10	<0.10
Chile: Santiago	23	<0.10	<0.10	<0.10
Jamaica: Kingston	25	1.32	<0.10	<0.32
Peru: Lima	16	<0.10	<0.10	<0.10
Venezuela: Caracas	21	0.12	<0.10	<0.10
West Indies: Trinidad	20	0.11	<0.10	<0.10
Pan American summary	120	1.32	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.

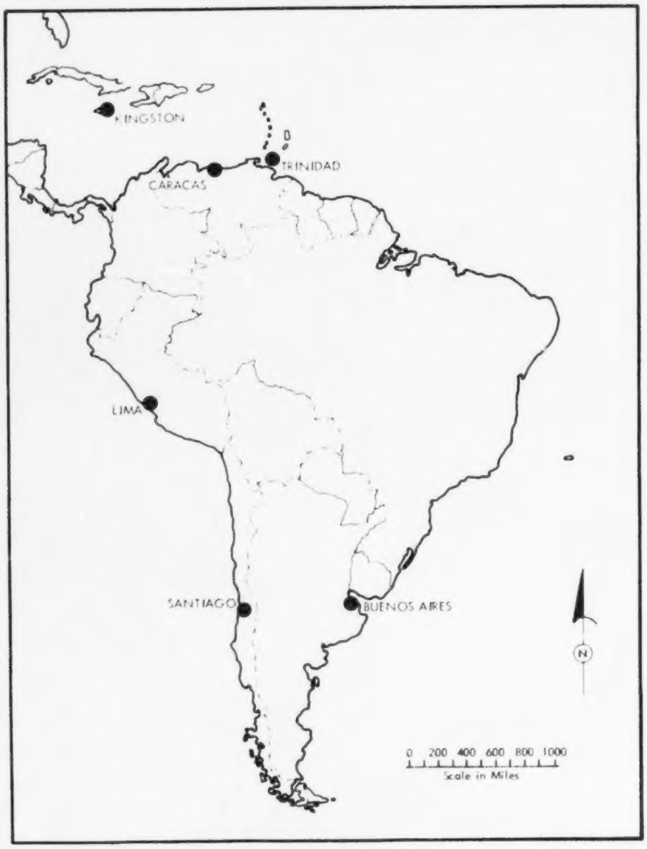

Figure 5. Pan American Air Network sampling stations

5. Fallout in the United States and Other Areas July–December 1965[2]

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and 35 other selected points in the Western Hemisphere (figure 6) covering the period from July through December 1965, are summarized in tables 6 and 7. All the stations of the 80th Meridian Network, except Washington, D.C., are represented.

To facilitate the accurate storage, retrieval, and handling of data generated from the monthly fallout collections network, all data obtained are transcribed onto punched cards. To accomplish this transcription, several rigid criteria were applied to the data. One condition was that only monthly data were punched onto the cards. In the few cases where collections were incomplete or where collection times overlapped calendar months, the data were corrected to yield monthly values by interpolation using rainfall and observed concentrations in rainfall as guides. Where any corrections to the data have been made, they are so indicated. In every case, the best estimate of the true strontium-90 deposition is listed.

Table 6. Strontium-90 fallout in the United States, HASL, July–December 1965

Sampling location and type of collection			Deposition, nCi/m²					
			July	Aug	Sept	Oct	Nov	Dec
Ala:	Birmingham	(pot)	0.96	0.22	0.36	0.05	0.15	0.20
Alaska:	Anchorage	(col)	0.35	0.40	0.29	0.05	0.12	NS
	Barrow	(col)	[a]0.06	[a]0.07	T	0.02	0.07	0.02
	Cold Bay	(col)	0.46	0.29	1.10	0.15	NS	0.46
	Fairbanks	(col)	0.25	0.29	0.14	0.28	0.06	NS
	Juneau	(col)	0.27	0.31	1.55	NS	0.08	0.18
	Nome	(col)	0.05	0.03	NS	[a]0.02	[a]0.01	0.01
Calif:	W. Los Angeles	(pot)	0.05	0.05	0.11	0.01	0.54	0.09
	Palo Alto	(pot)	0.02	0.02	0.02	T	0.55	0.18
	San Francisco	(col)	0.01	T	0.01	T	0.25	0.41
Colo:	Denver	(col)	0.67	0.13	0.24	0.02	T	0.61
Fla:	Coral Gables	(pot)	0.36	0.43	0.29	0.18	0.04	0.08
	Miami	(col)	0.48	0.22	0.12	0.17	T	1.12
Hawaii:	Hilo	(col)	NS	0.70	0.23	0.26	0.73	0.13
	Honolulu	(pot)	0.39	0.14	0.20	0.25	0.01	0.30
	Lihue	(col)	0.16	0.14	0.13	NS	0.25	0.10
	Mauna Loa	(col)	0.07	T	0.07	0.04	0.02	0.03
Ill:	Argonne	(pot)	0.36	0.39	0.59	0.15	0.07	0.17
La:	New Orleans	(col)	0.30	0.27	0.25	0.05	0.06	0.11
Minn:	International Falls	(col)	0.56	0.25	0.44	0.07	0.05	0.04
Mo:	Columbia	(col)	0.32	0.28	0.58	0.18	0.20	0.08
Mont:	Helena	(col)	0.53	0.29	0.25	0.10	0.05	0.05
N.J:	Westwood	(pot)	0.62	0.34	0.15	0.18	0.18	0.13
N.Y:	New York	(pot)	0.55	0.39	0.11	0.19	0.15	0.11
N. Dak:	Williston	(col)	0.46	0.30	0.30	NS	0.09	0.09
Ohio:	Wooster	(pot)	0.18	0.30	0.54	0.03	0.11	0.06
Okla:	Midwest City	(pot)	0.63	0.71	0.17	0.06	0.07	0.44
	Tulsa	(pot)	NS	0.27	0.31	0.05	0.04	0.24
Ore:	Medford	(col)	0.05	0.32	0.02	0.10	0.11	0.22
S.C:	Columbia	(col)	0.48	0.35	0.23	0.22	0.10	0.01
S. Dak:	Vermillion	(pot)	1.21	0.36	0.62	0.08	1.32	0.08
Tenn:	Chattanooga	(pot)	0.39	0.16	0.12	0.08	0.25	0.06
Tex:	Dallas	(col)	T	0.10	0.91	0.07	0.06	0.07
	El Paso	(col)	0.12	0.11	0.18	0.06	0.04	0.19
	Houston	(col)	0.16	0.12	0.12	0.22	0.12	0.15
Utah:	Salt Lake City	(pot)	0.18	0.32	0.27	0.08	0.13	0.15
Va:	Sterling	(col)	0.68	0.24	0.10	0.08	0.10	0.08
Wash:	Seattle	(pot)	0.10	0.25	0.09	0.11	0.22	0.26
	Seattle	(pot)	0.10	0.51	0.20	0.08	0.30	0.35
	Tatoosh Island	(col)	0.11	0.13	0.30	0.37	0.27	0.51
Wis:	Appleton	(pot)	0.32	0.51	0.27	0.17	0.20	0.17
	Green Bay	(col)	0.54	0.46	0.46	0.04	0.14	0.33

[a] Proportioned from originally consolidated data.
NS, no sample reported.
T, trace or zero.

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[2] The data in this article were taken from Fallout Program Quarterly Summary Report, HASL 172:A-1–A-164; B-1–B-21 (July 1, 1966).

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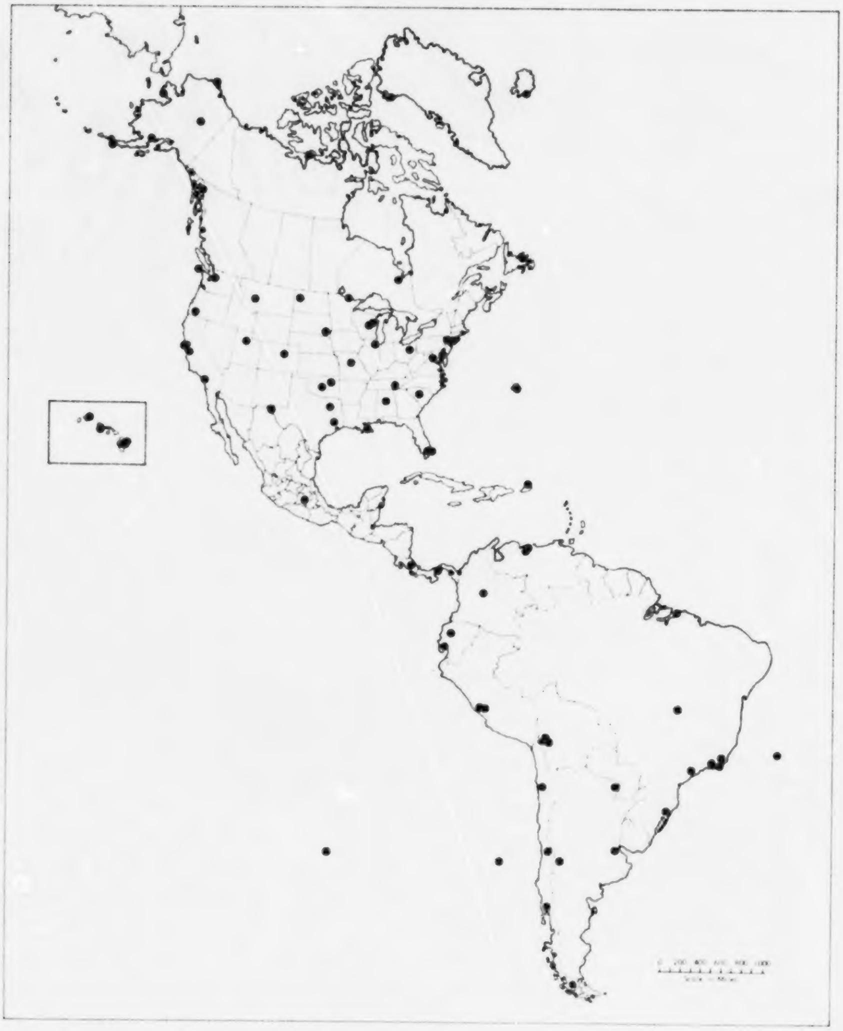
0 200 400 600 800 1000
Scale in Miles

Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 7. Strontium-90 fallout in North and South America, HASL, July–December 1965

Sampling location and type of collection		Deposition, nCi/m²					
		July	Aug	Sept	Oct	Nov	Dec
Argentina:	Buenos Aires (col)	0.07	0.08	0.17	0.20	0.12	0.13
	Formosa (col)	0.02	0.12	0.13	0.16	0.13	0.22
	Malargue (col)	0.03	0.08	0.02	0.08	0.04	NS
Bermuda:	Kindley AFB (col)	0.03	0.07	0.16	0.05	0.06	T
Bolivia:	Chacaltaya (col)	0.01	0.01	0.03	0.07	0.06	T
	La Paz (Ovejuyo) (col)	T	0.03	0.03	0.02	0.10	T
	La Paz (city) (col)	T	0.30	0.04	0.05	0.03	0.05
Brazil:	Belem (col)	0.03	0.03	0.07	0.07	0.14	0.35
	Brasilia (pot)	T	T	T	NS	NS	NS
	Itaici Sao Paulo (pot)	0.03	0.02	0.09	0.02	NS	NS
	Nova Friburgo (pot)	0.01	0.07	0.06	0.18	T	0.28
	Rio de Janeiro (col)	0.27	0.86	0.31	0.21	0.04	0.13
	San Jose Dose Campos (pot)	0.03	T	0.02	0.05	NS	NS
	Sao Leopoldo (pot)	0.12	0.16	0.37	NS	0.13	0.13
	Trinidade Island (col)	0.05	0.12	0.10	T	T	NS
Canada:	Newfoundland (col)	0.29	0.38	0.28	0.15	T	0.07
	Moosonee (col)	0.71	0.40	0.20	0.29	0.08	0.03
Canal Zone:	Miraflores (col)	0.05	0.07	0.07	0.05	0.04	0.21
Chile:	Antofagasta (col)	T	0.02	T	NS	NS	NS
	I. Alejandro Selkirk (col)	T	0.69	0.10	0.22	0.08	NS
	Easter Island (col)	0.10	0.10	NS	NS	NS	NS
	Puerto Montt (col)	0.26	0.36	0.11	0.22	T	NS
	Punta Arenas (col)	0.07	0.10	0.03	0.02	0.08	0.05
	Santiago (pot)	0.39	0.05	0.21	NS	NS	0.05
	Santiago (col)	0.48	0.17	T	0.06	0.28	0.45
Colombia:	Bogota (pot)	T	0.01	NS	NS	NS	NS
Costa Rica:	Turrialba (col)	0.61	0.08	0.06	0.02	0.04	0.03
Equador:	Guayaquil (col)	NS	NS	NS	NS	0.14	0.11
	Quito (col)	0.01	0.01	T	0.02	T	0.10
Greenland:	Thule (col)	0.17	0.13	0.11	0.01	0.02	NS
Iceland:	Keflavik (col)	0.14	0.13	0.10	0.46	0.05	0.07
Mexico:	Mexico City (col)	0.17	0.06	0.01	0.09	T	0.03
Peru:	Lima (col)	[a]0.01	T	0.13	0.05	0.04	0.15
	Lima (col)	[a]0.01	[a]0.03	0.13	0.06	T	NS
Puerto Rico:	San Juan (col)	0.32	0.32	0.20	0.10	0.05	0.14
Venezuela:	Caracas (site 1) (col)	0.12	0.16	0.37	T	T	NS
	Caracas (site 2) (col)	NS	NS	0.07	0.06	T	T

[a] Indicates proportioned from originally consolidated data.
T, trace or zero.
NS, no sample reported.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods.

Other radionuclides

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have analyzed monthly pot samples for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for strontium-89, strontium-90, cesium-137, cerium-144, zirconium-95, manganese-54, and iron-55 at each station are presented in table 8. In June 1965, routine reporting of manganese-54, strontium-89, zirconium-95, and cesium-137 was discontinued for the above locations. The reported depositions of manganese-54 and iron-55 have been corrected for decay to October 15, 1961. The remaining radionuclide data have been corrected for decay to the midpoint of the sampling month.

Table 8. HASL, radiochemical analyses of pot fallout samples at 6 U.S. sites, fission product and "tracer" radionuclides in monthly collections, July–December 1965

Sampling location	Precipitation, mm						Iron-55, nCi/m²					
	July	Aug	Sept	Oct	Nov	Dec	July	Aug	Sept	Oct	Nov	Dec
California, Palo Alto	T	T	T	T	122.9	81.3	1.26	<0.39	0.88	<0.17	5.21	1.87
New Jersey, Westwood	80.0	116.1	77.2	61.2	47.8	43.4	4.79	3.22	1.40	1.74	2.22	1.49
Oklahoma, Oklahoma City	48.3	127.5	106.4	33.5	1.0	68.6	5.87	8.07	2.96	0.80	1.35	4.21
Tennessee, Chattanooga	114.6	115.3	117.6	22.6	101.3	21.3	3.28	1.41	1.29	1.13	2.52	0.96
Washington, Seattle [•]	11.9	39.1	21.1	45.7	120.6	144.3	<0.54	2.59	1.11	0.92	1.82	0.02
Wisconsin, Appleton	63.5	94.2	199.9	47.5	47.2	67.0	2.79	4.71	3.13	1.64	2.64	1.94
	Strontium-90, nCi/m²						Cerium-144, nCi/m²					
California, Palo Alto	0.02	0.02	0.02	T	0.55	0.18	0.11	0.05	0.10	0.03	1.24	0.66
New Jersey, Westwood	0.62	0.34	0.15	0.18	0.18	0.13	1.95	1.15	0.48	0.52	0.47	0.27
Oklahoma, Oklahoma City	0.63	0.71	0.17	0.06	0.07	0.44	2.58	2.31	0.63	0.21	0.24	1.74
Tennessee, Chattanooga	0.39	0.16	0.12	0.08	0.25	0.06	1.55	0.56	0.32	0.27	0.55	0.20
Washington, Seattle	0.10	0.25	0.09	0.11	0.22	0.26	0.54	1.20	0.37	0.38	1.02	0.50
Wisconsin, Appleton	0.32	0.51	0.27	0.17	0.20	0.17	1.71	1.73	0.83	0.47	0.42	0.47

[•] Only Seattle samples analyzed for manganese-54, strontium-89, zirconium-95, and cesium-137, the results for July and August being respectively as follows: 0.72, 1 58; 0.07, 0.07; 0.07, 0.03, 0.19, and 0.39 nCi/m².

T, trace or zero.

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, APRIL-JUNE 1965[1]

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium-90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium-90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available for older children, but it presents some difficulties in the case of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for analysis as a basis for comparison with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. Procedures of sample collection and preparation were presented earlier (*2*). Strontium-90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of analytical quality control, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, specially prepared animal and adult human bone ash are analyzed in replicate as a continuing check on analytical sensitivity and accuracy.

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[1] Period during which deaths or surgical procedures occurred.

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Table 1. Strontium-90 in human bone, deaths or surgical procedures during April–June 1965

Sampling region and State	Sex	Bone type[a]	Age at death[b] (years)	Strontium-90, pCi/g of: Ash	2 σ error	Calcium	Bone
Northeast:							
Mass	F	V	0(11 mo)	1.57	0.18	4.78	0.12
Mass	M	V	4	0.81	0.10	2.25	0.06
Mass	F	V	5	1.16	0.13	3.36	0.08
Mass	M	V	6	1.38	0.13	3.97	0.12
N.Y	M	V	6	1.69	0.13	4.71	0.15
Mass	M	V	7	0.87	0.10	2.39	0.09
Mass	F	V	7	1.40	0.14	4.08	0.11
Mass	F	V	8	1.16	0.11	3.15	0.13
Mass	F	V	9	1.89	0.12	5.51	0.26
Mass	M	V	10	0.71	0.08	1.98	0.07
Mass	M	V	10	0.95	0.08	2.69	0.09
N.Y	M	V	12	0.71	0.07	1.94	0.08
Mass	F	V	12	0.93	0.10	2.56	0.12
Mass	F	V	13	1.04	0.07	2.88	0.12
Mass	F	V	13	1.34	0.12	3.62	0.12
Mass	F	V	13	1.07	0.07	3.02	0.11
Mass	F	V, R	15	1.02	0.07	2.90	0.10
N.Y	M	V	15	0.65	0.07	1.77	0.08
Mass	F	V	16	0.79	0.06	2.11	0.10
Mass	M	V	16	0.96	0.07	2.57	0.13
N.Y	M	V	18	0.78	0.06	2.14	0.10
N.Y	M	V	18	0.64	0.06	1.67	0.09
N.Y	M	V	18	0.57	0.05	1.52	0.06
Mass	M	V	20	0.98	0.06	2.64	0.10
N.Y	F	V	21	0.48	0.05	1.26	0.07
Mass	F	V	21	0.86	0.06	2.21	0.16
Mass	M	V	22	0.93	0.07	2.47	0.13
N.Y	M	V	22	0.97	0.07	2.59	0.12
N.Y	M	V	23	0.56	0.05	1.49	0.08
Pa	M	V	24	0.87	0.08	2.30	0.09
Mass	M	V	25	0.90	0.06	2.35	0.14
N.Y	F	V	25	0.55	0.05	1.48	0.06
Central:							
Wis	F	V	0(9 mo)	2.04	0.20	5.43	0.24
Wis	M	V	0(9 mo)	2.01	0.21	5.73	0.16
Ohio	M	V	1	1.59	0.17	4.31	0.17
Wis	M	V	2	0.96	0.09	2.74	0.09
Wis	F	V	2	1.06	0.13	3.03	0.09
Ohio	F	V	3	2.12	0.15	5.45	0.43
Wis	F	V	3	1.32	0.12	3.71	0.10
Minn	M	V	3	1.98	0.18	5.40	0.18
Wis	M	V	5	0.93	0.07	2.56	0.08
Ohio	M	V	6	0.95	0.11	2.38	0.13
Minn	F	V	10	1.49	0.10	4.06	0.14
Minn	M	V	11	1.91	0.11	5.19	0.14
Ohio	M	V	11	1.05	0.11	2.87	0.18
Ohio	F	V	11	0.82	0.08	2.21	0.14
Ohio	M	V	12	0.90	0.08	2.32	0.15
Ohio	F	V	12	0.89	0.08	2.30	0.14
Ohio	F	V	12	1.12	0.06	3.00	0.20
Ohio	F	V	14	0.99	0.06	2.52	0.15
Ohio	M	V	15	0.96	0.06	2.49	0.19
Minn	F	V	15	0.62	0.05	1.61	0.09
Minn	M	V	16	0.78	0.06	2.13	0.09
Ohio	M	V	18	0.86	0.06	2.23	0.15
Ohio	M	V	18	1.04	0.06	2.65	0.18
Ohio	M	V	19	0.76	0.06	1.94	0.13
Ohio	M	V	21	0.89	0.06	2.27	0.17
Ohio	M	V	22	0.75	0.06	1.92	0.10
Ohio	F	V	23	0.78	0.06	1.96	0.14
Ohio	M	V	23	0.85	0.05	2.22	0.14
Ohio	M	V	24	0.74	0.06	1.94	0.14
Ohio	M	V	24	0.63	0.05	1.66	0.09
Ohio	M	V	25	0.55	0.04	1.40	0.10
Delta:							
La	F	V	2	2.56	0.17	7.07	0.29
La	M	V, R	2	2.13	0.16	5.74	0.20
La	F	V	5	2.40	0.11	6.40	0.31
La	M	F	9	1.00	0.07	2.55	0.12
La	M	R	10	1.30	0.10	3.46	0.26
La	M	R	12	1.09	0.11	2.82	0.20
La	F	V, R	16	0.48	0.06	1.25	0.08
La	M	V	22	1.07	0.07	2.77	0.16
La	M	V, R	24	0.53	0.05	1.42	0.08
Northwest:							
Alaska	F	R	12	1.25	0.19	3.13	0.39
Alaska	F	R	17	1.76	0.16	4.31	0.65
Alaska	F	R	25	0.46	0.13	1.17	0.16
Southwest:							
Calif	F	V, R	0(13 da)	0.46	0.06	1.23	0.05
Calif	F	V, R	0(2 mo)	0.97	0.10	2.98	0.05
Ariz	M	V	1	1.21	0.09	3.27	0.14
Calif	M	V, R	1	1.32	0.10	3.60	0.12
Calif	F	V	2	1.63	0.19	4.54	0.17
Calif	F	V	5	1.20	0.11	3.58	0.06
Calif	M	V	16	0.90	0.09	2.48	0.11
Tex	M	V	17	0.65	0.09	1.72	0.07

[a] Type of bone: V, vertebrae; R, rib; F, femur.

[b] Age given as of last birthday prior to death.

The results of laboratory analyses for strontium–90 in individual bones from persons dying during the second quarter of 1965 are presented in table 1 in order of increasing age within each sampling region. The sampling regions have been defined in an earlier report (*5*). The data are reported as picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Table 2 summarizes the average concentrations of strontium–90 in human bone by 5-year age groups for each year from 1961 through the first half of 1965.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2-4*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
1962–1964	April 1966
First quarter 1965	June 1966

Table 2. Strontium-90 in human bone samples for 5-year groups, 1961–1964 and first half 1965

Age group [a]	Year of death [b]	Number	Strontium-90, pCi/g calcium		
			Mean [c]	Minimum	Maximum
0–4 years	1961	3	2.7	1.8	3.4
	1962	50	3.3	0.8	9.7
	1963	44	4.5	1.0	13.0
	1964	67	4.4	1.0	8.7
	1965, first half	38	4.1	1.2	8.9
5–9 years	1961	1	2.7	—	—
	1962	33	2.7	1.0	9.4
	1963	43	3.9	1.8	9.1
	1964	64	3.6	1.2	7.0
	1965, first half	26	3.0	1.3	6.4
10–14 years	1961	4	1.8	1.2	2.8
	1962	28	2.1	0.8	3.5
	1963	47	2.9	1.1	9.0
	1964	56	3.1	0.9	5.7
	1965, first half	24	3.0	1.6	5.2
15–19 years	1961	0	—	—	—
	1962	31	2.2	0.9	4.6
	1963	73	2.6	1.0	7.0
	1964	58	2.9	1.2	8.0
	1965, first half	28	2.3	1.3	4.7
20–24 years	1961	0	—	—	—
	1962	29	1.8	0.9	3.5
	1963	61	2.2	0.9	5.0
	1964	52	2.2	0.8	4.3
	1965, first half	25	1.9	1.0	2.8

[a] Age taken as of last birthday prior to death; ages greater than 24 years not included.

[b] Or surgical procedure.

[c] Mean values given in this table for the various years within each age group may not be directly comparable because of variations in sampling locations from year to year; however, the data are given as a summary of presently available known results.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory, Atomics International, National Reactor Testing Station, and the Oak Ridge Area.

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[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." These are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Argonne National Laboratory July–December 1965 [3]

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually dispersed by air and water, the environmental monitoring program at Argonne has concentrated on these media. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. Sampling on charcoal for radioactive iodine was conducted on the site only. Iodine–131 concentrations greater than the detection limit of 0.1 pCi/m^3 were found in the onsite samples during portions of July, August, October, and November. The maximum concentration in any one sample was 10 pCi/m^3, or 10 percent of the AEC standard. The iodine–131 was accidentally released from two of the Argonne buildings in the 300 area. Surface deposition was confined to within 1,000 yards of the point of release. None was detected off the site. The average iodine–131 concentration for the entire year was about 0.3 pCi/m^3, or 0.3 percent of the AEC standard.

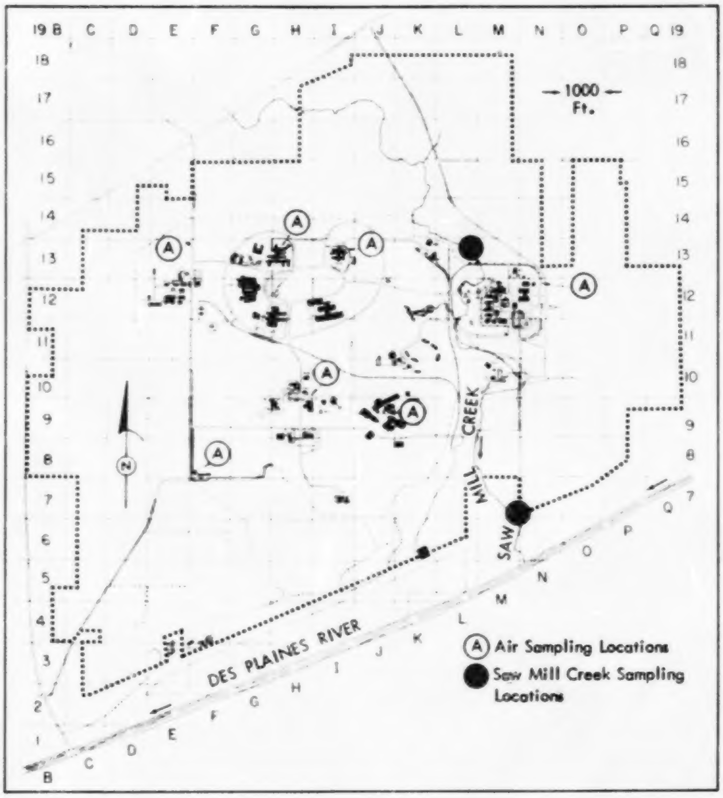

Figure 1. Sampling locations on the site of Argonne National Laboratory

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[3] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December 1965," University of Chicago, Lemont, Illinois.

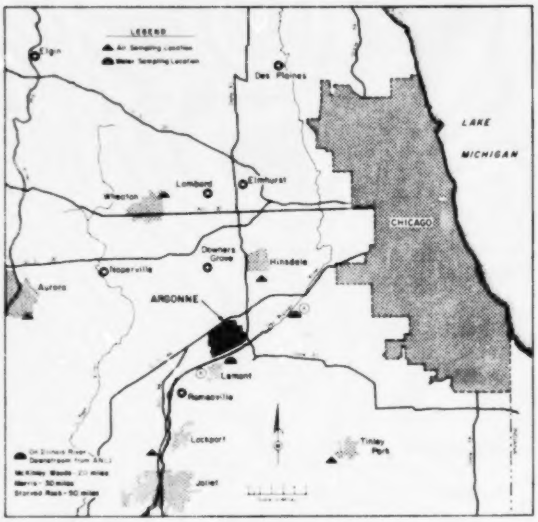
LEGEND
Air Sampling Location
Water Sampling Location
Elgin
Des Plaines
LAKE
MICHIGAN
Lombard
Elmhurst
Wheaton
CHICAGO
Downers Grove
Hinsdale
Naperville
Aurora
ARGONNE
Lemont
Romeoville
Lockport
Tinley Park
Joliet
On Illinois River Downstream from ANL
McKinley Woods - 20 miles
Morris - 30 miles
Starved Rock - 50 miles

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

The total alpha and beta activities in the air-filter samples are summarized in table 1. The alpha activities were normal both on and off the site and were in the range found in previous years. The beta activity was due primarily to fission and neutron activation products from nuclear detonations. Activity from the Chinese atmospheric nuclear detonation of May 14, 1965, was observed on the air-filter samples from May 21 through July. The average beta activity for the year, 0.25 pCi/m^3, was about one-fourth of the 1964 average. The similarity between alpha and beta activities on and off the site indicates that Argonne did not add significantly to the particulate airborne activity of the environment. The concentrations of specific fission products given in table 2 support this conclusion. Significant releases by Argonne would have been detected in the form of an increase in the onsite levels over the offsite levels.

Water monitoring

Argonne waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the waste water on the radioactivity in the creek. Radioactivity from Argonne waste water, in amounts well below the AEC standards, was found in some samples of Sawmill Creek water collected below the discharge. The concentrations of radioactive materials at this location are summarized in table 3. The table gives the average and max-

Table 1. Total alpha and beta activities in air-filter samples, July–December 1965 [a]

Month 1965	Location	Number of samples	Alpha activity, pCi/m^3			Beta activity, pCi/m^3		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	27	0.0042	0.0027	0.0064	0.37	0.17	0.65
	Offsite	22	0.0046	0.0022	0.0095	0.39	0.20	0.73
August	Onsite	28	0.0049	0.0022	0.0071	0.16	0.09	0.23
	Offsite	23	0.0035	0.0017	0.0052	0.17	0.08	0.25
September	Onsite	24	0.0033	0.0022	0.0061	0.09	0.03	0.25
	Offsite	18	0.0029	0.0014	0.0084	0.08	0.05	0.12
October	Onsite	26	0.0035	0.0021	0.0063	0.09	0.05	0.41
	Offsite	22	0.0032	0.0018	0.0054	0.08	0.05	0.11
November	Onsite	27	0.0047	0.0027	0.0082	0.08	0.05	0.13
	Offsite	22	0.0042	0.0028	0.0060	0.08	0.06	0.10
December	Onsite	25	0.0044	0.0029	0.0063	0.08	0.04	0.12
	Offsite	19	0.0046	0.0028	0.0072	0.09	0.05	0.18
Summary	Onsite	157	0.0042	0.0021	0.0082	0.15	0.03	0.65
	Offsite	126	0.0038	0.0014	0.0095	0.15	0.05	0.73
Annual summary	Onsite	306	0.0039	0.0004	0.0082	0.24	0.03	1.13
	Offsite	241	0.0039	0.0013	0.0095	0.25	0.05	1.20

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within 4 days by radioactive decay.

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Table 2. Gamma-ray activity in air-filter samples, July–December 1965

Nuclide	Location	Gamma air activity, pCi/m³							
		July	Aug	Sept	Oct	Nov	Dec	Average	Annual average
Antimony-125	Onsite Offsite	0.01 0.01	0.03 0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01
Barium-lanthanum-140	Onsite Offsite	<0.02 <0.02	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.02 <0.02
Cerium-144	Onsite Offsite	0.11 0.12	0.05 0.06	0.03 0.02	0.01 0.01	0.01 0.01	0.01 0.01	0.04 0.04	0.08 0.08
Cesium-137	Onsite Offsite	0.02 0.02	0.01 0.02	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	0.01 0.01	0.02 0.02
Ruthenium-rhodium-106	Onsite Offsite	0.01 0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	0.03 0.03
Zirconium-niobium-95	Onsite Offsite	0.02 0.02	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01	<0.01 <0.01

Table 3. Radioactivity in Sawmill Creek water below waste-water discharge July–December and calendar year 1965

Nuclide	July–December 1965				Calendar year 1965			
	Concentration (pCi/liter)		Percent of AEC Standard		Concentration (pCi/liter)		Percent of AEC standard	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Barium-140	—	<2	—	<0.007	—	<2	—	<0.007
Cesium-137	1.8	3.4	0.009	0.017	1.5	3.4	0.008	0.017
Cobalt-58	—	<5	—	<0.005	—	<5	—	<0.005
Cobalt-60	<1	1.5	<0.002	0.003	1.0	14.1	0.002	0.028
Hydrogen-3 (tritium)	<4,000	6,000	<0.13	0.2	<4,000	6,000	<0.13	0.2
Iodine-131	—	<3	—	<1	—	<3	—	<1
Plutonium	0.09	0.95	0.002	0.019	0.06	0.95	0.001	0.019
Strontium-89	—	<2	—	<1.07	—	<2	—	<0.07
Strontium-90	2.0	4.7	0.67	1.6	2.4	5.5	0.80	1.8
Technetium-99	—	<0.5	—	<0.0002	—	<0.5	—	<0.0002
Thorium-232	0.09	1.1	0.005	0.055	0.10	1.1	0.005	0.055
Thorium-protactinium-234	2.1	4.7	0.011	0.024	1.7	7.7	0.009	0.039
Uranium	2.6	5.9	0.007	0.015	2.7	10.6	0.007	0.027

imum concentrations in pCi/liter, as well as the corresponding percentage of the AEC standards.

A comparison of these concentrations with those above the discharge indicates that essentially all of the thorium, plutonium, cesium-137, cobalt-60, and tritium, and about two-thirds of the thorium-234 and uranium originated in the waste water, while most of the strontium-90 was due to fallout.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in these two streams is important in determining the effect of Argonne operations on the environmental radioactivity. The alpha, beta, and uranium activities found in these streams are summarized in table 4. Des Plaines River water was also analyzed for the other nuclides found in Sawmill Creek, and, as was the case for the results in table 4, no significant differences in radioactivity between sampling locations of

Table 4. Average radioactivity in Des Plaines and Illinois River water, July–December and calendar year 1965

Location	July–December 1965			Calendar year 1965		
	Alpha activity (pCi/liter)	Uranium (pCi/liter)	Beta activity (pCi/liter)	Alpha activity (pCi/liter)	Uranium (pCi/liter)	Beta activity (pCi/liter)
Des Plaines River [a] (above Sawmill Creek)	2.7	2.3	16	2.4	2.1	18
Des Plaines River [b] (below Sawmill Creek)	2.7	2.2	15	2.4	1.9	18
Illinois River [c]	2.4	2.0	8	2.4	2.1	11

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average of two sampling locations: McKinley Woods State Park and Morris. See figure 2 for all sampling locations.

the river could be found. Dilution of Sawmill Creek water in the Des Plaines River was sufficient to reduce the activity in the Creek to undetectable levels in the river. The alpha activities in the Des Plaines and Illinois Rivers were in the normal range and similar to earlier values. The natural beta activity in the Des Plaines and Illinois Rivers varies between 5 and 10 pCi/liter. The additional beta activity in these streams was due to fallout. There was no indication of activity from Argonne operations in either stream.

Milk monitoring

Three samples of locally produced raw milk were analyzed each month for the fission products most likely to be present. Barium–140 and strontium–89 were found only in the June samples, at average concentrations of 24 and 14 pCi/liter, respectively. These activities are assumed to have originated in the Chinese test of May 14, 1965. Cesium–137 and strontium–90 were present in most samples during the year. Their average concentrations were 47 and 12 pCi/liter, respectively. The average strontium–90 concentration was similar to that of 1964, while the cesium–137 concentration decreased by about a factor of four. These fission products were due to fallout from nuclear detonations and were not related to Argonne operations.

Summary

Fallout activity was present in all types of samples and at all locations throughout the year, but in much lower concentrations than in 1964. Argonne's contribution to the environment was confined to Sawmill Creek below the wastewater discharge and to radioiodine detected in air and grass collected on the Argonne site. The concentrations of radioactive substances added to the environment during the year by Argonne were considerably less than the AEC standards and did not constitute a health hazard.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1961	May 1962
Calendar year 1962	May 1963
Calendar year 1963	August 1964
January–June 1964	March 1965
July–December 1964	September 1965
January–June 1965	March 1966

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2. Atomics International
July–December 1965[1]

North American Aviation, Inc.
Canoga Park, California

Atomics International, a Division of North American Aviation, Inc., has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants and for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, California, approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 3.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air

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[1] Summarized from "Environmental Monitoring, Semiannual Report, January 1 to June 30, 1965," Atomics International.

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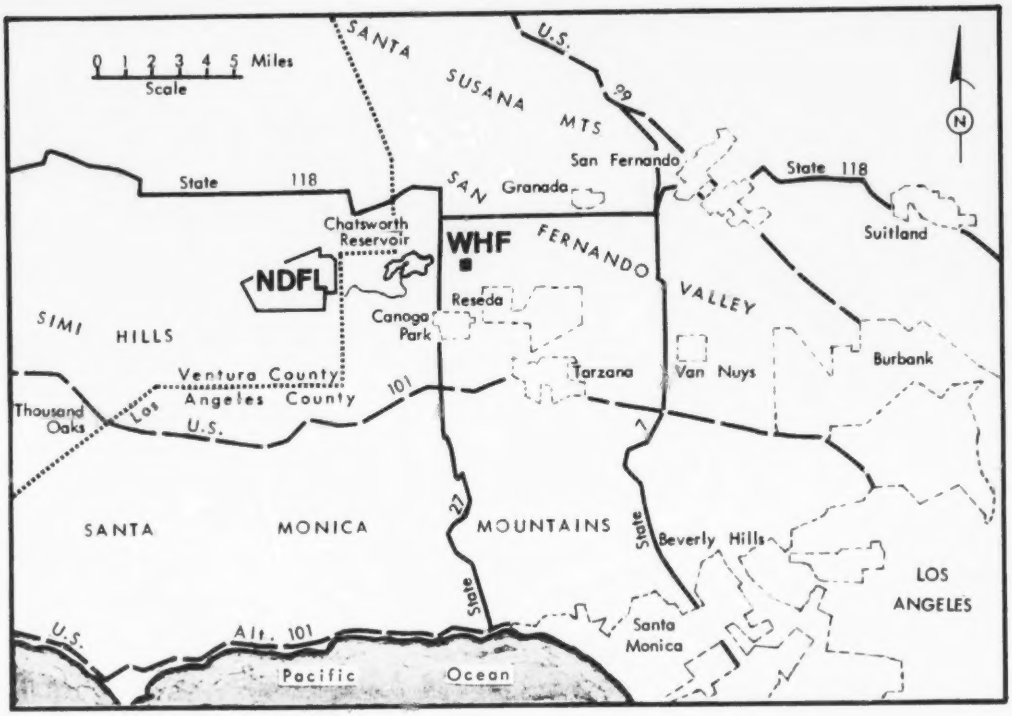
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NDFL
VALLEY
SIMI HILLS
Reseda
Canoga Park
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
101
U.S.
Thousand Oaks
7
SANTA MONICA MOUNTAINS
27
State
State
Beverly Hills
LOS ANGELES
Santa Monica
U.S.
Alt. 101
Pacific Ocean

Figure 3. Atomics International facilities and vicinity

monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 29 cubic meters. The average concentration of airborne particulates is presented in table 5.

Table 5. Beta-gamma radioactivity of airborne particulates, NDFL, 1965

Location	First half 1965		Second half 1965	
	Number of samples	Average concentration (pCi/m³)	Number of samples	Average concentration (pCi/m³)
Headquarters	182	2.0	301	0.12
NDFL	69	1.9	993	0.09

Water monitoring

Process water used at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Potable water is delivered to the site by a vendor and is not analyzed. Well water is sampled monthly from the supply line at two locations. The average well water radioactivity is presented in table 6.

Soil, vegetation, and water are sampled monthy at Chatsworth Reservoir, which is operated by the Los Angeles City Department of

Table 6. Well water radioactivity, NDFL, 1965

Activity	First half 1965		Second half 1965	
	Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.22	12	<0.22
Beta-gamma	12	<6.5	12	5.5

Water and Power. Soil and vegetation radioactivity data for the reservoir are averaged into data presented in tables 7 and 8. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 9.

Table 7. Radioactivity in the soil, NDFL, 1965

Area	Activity	First half 1965		Second half 1965	
		Number of samples	Average concentration (pCi/g)	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.49	72	<0.44
	Beta-gamma	72	40	72	32
Offsite	Alpha	70	<0.51	72	<0.45
	Beta-gamma	70	30	72	27

Table 8. Radioactivity in vegetation, NDFL, 1965

Area	Activity	First half 1965		Second half 1965	
		Number of samples	Average concentration (pCi/g ash)	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	<0.62	72	<0.50
	Beta-gamma	72	177	72	146
Offsite	Alpha	70	0.78	72	<0.46
	Beta-gamma	70	156	72	121

Table 9. Chatsworth Reservoir water radioactivity, 1965

Sample	Activity	First half 1965		Second half 1965	
		Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	6	0.53	5	0.81
	Beta-gamma	6	9.8	5	7.3
Supply inlet	Alpha	6	0.44	6	0.78
	Beta-gamma	6	12.2	6	<5.9

In the laboratory, 500 ml of water is evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred to stainless-steel planchets, wetted with distilled water to produce a uniform sample distribution, redried under infrared lamps, and counted.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as onsite stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as offsite stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis.

Sample preparation consists of transferring the soils to Pyrex beakers and drying in a muffle furnace at 500°C. for approximately 8 hours. After cooling, the soil is sieved to obtain a uniform particle size. One-gram aliquots of the sieved soil are weighed and transferred to stainless-steel planchets. The soil is wetted in the planchet with acetone, agitated to obtain uniform sample thickness, re-dried, and counted. Radioactivity in soil is presented in table 8.

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season that do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and placed in ice cream cartons for transfer to the laboratory for analysis. Plant root systems are not routinely sampled.

Vegetation samples are first washed with tap water to remove foreign matter and then thoroughly rinsed in distilled water. Washed vegetation is placed in porcelain crucibles and ashed in a muffle furnace at 500°C. for approximately 8 hours, producing a completely oxidized ash. Three-hundred-milligram aliquots of pulverized ash from each crucible are weighed and transferred to stainless-steel planchets for counting.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Second half 1961	August 1962
Calendar year 1962	November 1963
Calendar year 1963	September 1964
First half 1964	March 1965
Second half 1964	September 1965
First half 1965	March 1966

3. National Reactor Testing Station July–December and Calendar Year 1965[5]

Health and Safety Division
U. S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area, which permits controlled releases of radioactivity from the projects with minimum hazard to sizable population groups. The NRTS surveillance program is conducted by the AEC's Idaho Operations Office. The monitoring program consists of periodic sampling of ground and surface waters, milk, wheat, and air. The locations at which these samples are taken are shown in figure 4. The results of the analysis of these samples are shown in table 10.

Offsite water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly. Most of these samples are taken from an area southwest of the NRTS, the prevalent direction of underground water flow. During 1965, 64 samples were collected on a semiannual basis from 32 sampling stations. The analytical results indicated no significant change from concentrations recorded during 1964. The average concentrations of alpha and beta emitters were no more than 4 percent and 9 percent of the AEC standards, respectively. The alpha activity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define

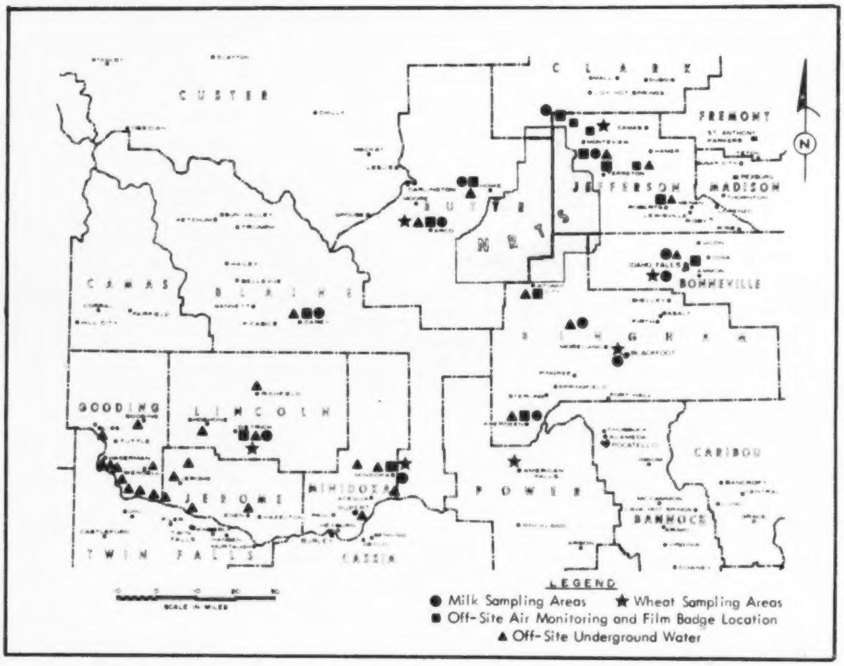
CUSTER
CLARK
FREMONT
MADISON
JEFFERSON
BUTTE
NRTS
BONNEVILLE
CAMAS
BLAINE
BINGHAM
GOODING
LINCOLN
CARIBOU
JEROME
MINIDOKA
POWER
BANNOCK
TWIN FALLS
CASSIA
N
SCALE IN MILES
LEGEND
● Milk Sampling Areas ★ Wheat Sampling Areas
■ Off-Site Air Monitoring and Film Badge Location
▲ Off-Site Underground Water

Figure 4. Environmental monitoring stations, National Reactor Testing Stations

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[5] Summarized from "Environmental Monitoring Report No. 17, Third and Fourth Quarters and Annual Summary 1965." U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

Table 10. Environmental monitoring data for the National Reactor Testing Station, July–December and calendar year 1965

Type of sample and units	July–December 1965						Calendar year 1965			
	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample	Number of stations	Maximum activity of single sample	Average activity per sample	AEC standard
Offsite underground water, pCi/liter	32	Semiannual	Alpha Beta	3 6	4 17	<4 8	32	4 29	<4 <9	100 100
Onsite production well water, pCi/liter	22	Biweekly	Alpha Beta	3 6	7 52	3 8	22	7 100	<4 <10	3,000 3,000
Offsite air, pCi/m^3	12	Continuous	Beta-gamma Iodine-131	1.6 3.6	56 12	<6 <4	[a] 15	56 12	<4 <4	100 100
Offsite milk, pCi/liter	12	Monthly	Iodine-131 Strontium-90	20 1.5	50 22	<21 <11	12	[b] 63 24	<23 <13	100 200
Offsite area monitoring badges, mR	12	Monthly	Gamma	10	<10	<10	[a] 15	<10	<10	170/yr

[a] Changed from 15 stations to 12 in April of 1965.

[b] This was the highest concentration measured at routine bulk sampling points. A concentration of 310 pCi/liter was the highest level observed in raw milk collected at individual farms.

possible sources of contamination. During 1965, 435 samples were collected from 22 sampling stations, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta emitters were no more than 0.2 percent and 0.4 percent of the AEC standards, reflecting no change from the previous year.

Offsite air monitoring

Normal operations of the present radiotelemetry system calls for hourly reports by each station. The reporting instruments and functions are:

1. Ion chamber: This instrument measures ambient radiation levels in mR/hr.
2. GM counters: HV–70 filter paper which collects airborne particulates is cycled to a GM tube once a day. One GM tube measures the buildup of particulate activity during the day and another measures the decay of the activity collected the previous day.
3. Scintillation counter: Air which has previously passed through the HV–70 particulate filter then passes through a carbon cartridge. For surveillance purposes, the activity collected by the carbon cartridge is measured hourly by the scintillation counter and is assumed to be iodine–131. This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 radiation telemetry stations indicate that the sum of the average concentrations of gaseous iodine–131 and particulate activity in the atmosphere was less than 8 percent of the AEC standard during 1965.

Offsite milk monitoring

Routine monthly analyses of iodine–131 and strontium–90 concentrations in milk were conducted during 1965. During the latter part of May, significant concentrations of iodine–131 were detected in the Idaho Falls area Grade A milk. Consequently, an intensive milk sampling program was initiated during the period May 25 through June 20, 1965. The highest concentration measured during this period was 310 pCi/liter. This increase in radioactivity was attributed to fallout from the Chinese nuclear test on May 14, 1965.

Of the 144 routine radioiodine analyses, only 10 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 10, the average iodine–131 levels, including the May through June samples, do not exceed 23 percent of the AEC standard. Strontium–90 concentrations in the same 144 samples showed a maximum concentration of 24 pCi/liter or 12 percent of the AEC standard with an average value of only 13 pCi/liter or 7 percent of the AEC standard.

Offsite area monitoring badges

Offsite film badges were collected monthly during 1965. The maximum radiation dose measured by film at a single location for the entire year was <120 mR of gamma radiation, based on 12 film changes and a detection limit of 10 mR gamma on each film. For the purpose of calculating the maximum does, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location.

Evaluation of the airborne effluent data from reactor operations in 1965 indicates that the actual offsite gamma dose from NRTS operations was less than 2 mR. This is less than two percent of natural background radiation. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100 to 150 mR/yr.

Wheat monitoring

Monitoring of wheat for radionuclides continued in 1965. In the eight samples analyzed, strontium-90 levels ranged from 11 to 37 pCi/kg with an average of 26 pCi/kg. Cesium-137 levels varied from 60 to 118 pCi/kg with an average of 88 pCi/kg. Analyses for manganese-54 in eight wheat samples collected in the fall of 1965 showed no activity above the detection limit of 100 pCi/kg. The average concentration of manganese-54 in 1964 wheat samples was 790 pCi/kg. This decrease may possibly be attributed to different weather conditions and fallout patterns during the two years under consideration. Although no guide pertaining to wheat has been established, the data indicated that local wheat could not be a significant contributor to the radiation dose received by local consumers.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1961	June 1962
Calendar year 1962	June 1963
Calendar year 1963	September 1964
January-June 1964	March 1965
July-December 1964	September 1965
January-June 1965	March 1966

4. Oak Ridge Area
July-December 1965[6]

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of eight stations which encircle the plant areas (figure 5) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 6). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

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[6] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge Area," compiled by the Applied Health Physics Section of the Health Physics Division, Oak Ridge National Laboratory.

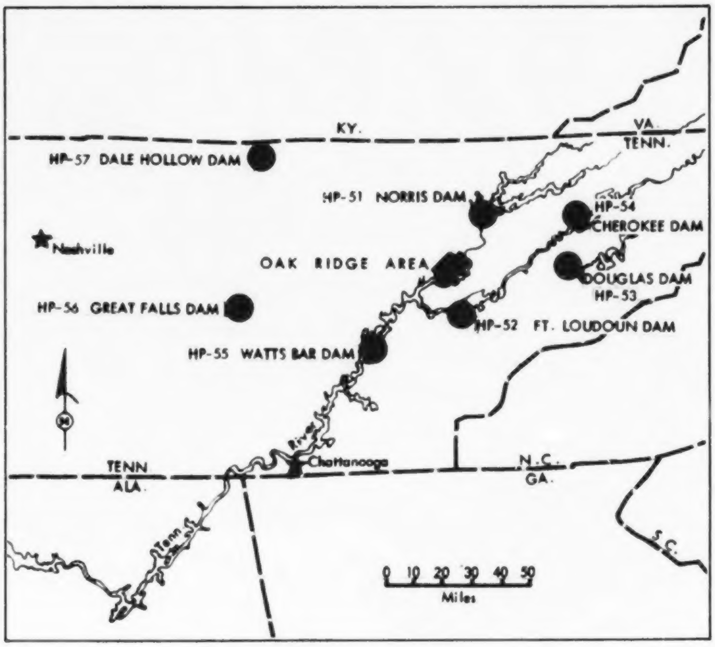
KY.
VA.
TENN.
HP-57 DALE HOLLOW DAM
HP-51 NORRIS DAM
HP-54
CHEROKEE DAM
Nashville
OAK RIDGE AREA
DOUGLAS DAM
HP-53
HP-56 GREAT FALLS DAM
HP-52 FT. LOUDOUN DAM
HP-55 WATTS BAR DAM
N
TENN
ALA.
Chattanooga
N.C.
GA.
S.C.
Tenn. R.
0 10 20 30 40 50
Miles

Figure 5. Remote air monitoring stations, Oak Ridge Area

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 11 and 12. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

Table 11. Long-lived gross beta particulate activity in air
Oak Ridge area, July–December 1965

Perimeter stations (see figure 5)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard	Perimeter stations (see figure 6)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard
HP-31	26	0.08	0.08	HP-51	26	0.08	0.08
HP-32	26	0.09	0.09	HP-52	26	0.08	0.08
HP-33	26	0.07	0.07	HP-53	26	0.09	0.09
HP-34	26	0.09	0.09	HP-54	26	0.08	0.08
HP-35	26	0.09	0.09	HP-55	25	0.09	0.09
HP-36	182	0.13	0.13	HP-56	25	0.08	0.08
HP-37	26	0.07	0.07	HP-57	26	0.08	0.08
HP-38	26	0.11	0.11	HP-58	22	0.09	0.09
Average		0.09	0.09	Average		0.08	0.08

Table 12. Long-lived gross alpha particulate activity in air
Oak Ridge area, July–December 1965

Perimeter stations (see figure 5)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard	Perimeter stations (see figure 6)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard
HP-31	26	0.005	0.25	HP-51	26	0.003	0.15
HP-32	26	0.008	0.40	HP-52	26	0.003	0.15
HP-33	26	0.005	0.25	HP-53	26	0.003	0.15
HP-34	26	0.005	0.25	HP-54	26	0.004	0.20
HP-35	26	0.010	0.50	HP-55	26	0.003	0.15
HP-36	182	0.017	0.85	HP-56	26	0.002	0.10
HP-37	26	0.005	0.25	HP-57	26	0.003	0.15
HP-38	26	0.005	0.25	HP-58	22	0.005	0.25
Average		0.008	0.40	Average		0.003	0.15

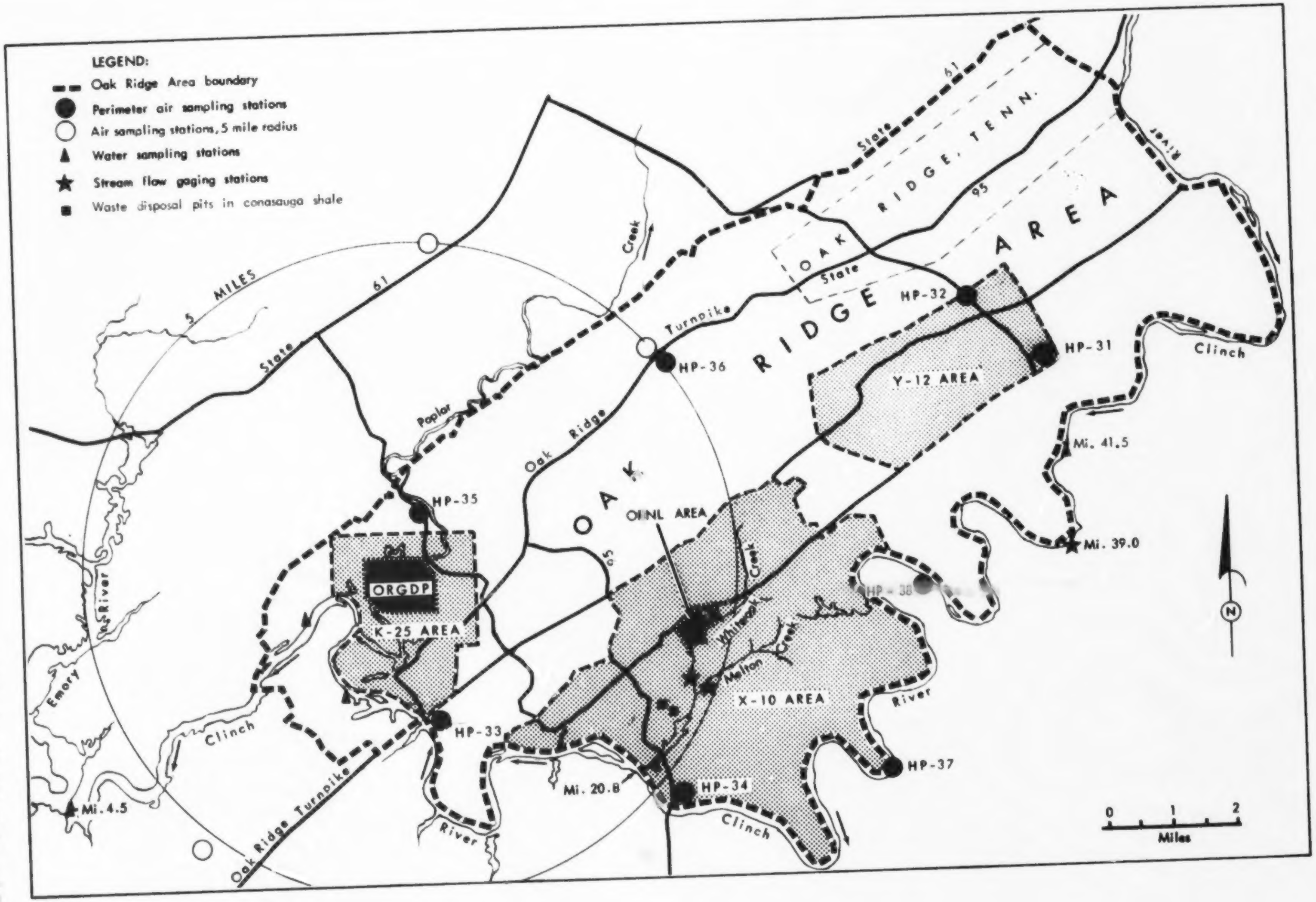
LEGEND:
Oak Ridge Area boundary
● Perimeter air sampling stations
○ Air sampling stations, 5 mile radius
▲ Water sampling stations
★ Stream flow gaging stations
■ Waste disposal pits in conasauga shale
OAK RIDGE AREA
OAK RIDGE, TENN.
State 61
95
State
HP-31
HP-32
HP-33
HP-34
HP-35
HP-36
HP-37
HP-38
Y-12 AREA
X-10 AREA
ORNL AREA
K-25 AREA
ORGDP
Clinch River
Emory River
Poplar Creek
Whiteoak Creek
Melton Creek
Creek
Oak Ridge Turnpike
5 MILES
Mi. 41.5
Mi. 39.0
Mi. 20.8
Mi. 4.5
N
0 1 2
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Figure 6. Oak Ridge Area environmental sampling locations

Milk monitoring

Raw milk is monitored for iodine–131 and strontium–90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge Area. Four stations, located more remotely with respect to Oak Ridge Operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge Area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of these radionuclides in raw milk are given in table 13.

Table 13. Radionuclides in raw milk, Oak Ridge area July–December 1965

Radionuclide and location	Concentration, pCi/liter		
	Maximum	Minimum [a]	Average
Iodine-131			
Immediate environs	19	<10	6.1
Remote environs	15	<10	5.9
Strontium-90			
Immediate environs	50	6.3	23
Remote environs	33	17	23

[a] Minimum detectable concentration of iodine-131 is 10 pCi/liter. In averaging, one-half of this value, 5 pCi/liter, was used for all samples showing a concentration less than 10 pCi/liter.

Water monitoring

Large-volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC standards. The radioactivity in White Oak Creek is measured, and values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Steam-gauging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, uranium, and the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The averages are given in table 14. No uranium was detected in Clinch River water samples during this period.

Table 14. Concentrations of major radionuclides in the Clinch River, July–December 1965

Radionuclide	Average concentration, pCi/liter		
	Location on Clinch River [a]		
	Mile 41.5 (Upstream)	Mile 20.8 [b] (Outfall)	Mile 4.5 (Downstream)
Strontium-90	0.5	0.5	1.3
Cerium-144	0.2	<0.1	0.3
Cesium-137	0.5	0.3	1.0
Ruthenium-106	3.2	4.2	6.1
Cobalt-60	ND	1.3	1.8
Zirconium-niobium-95	ND	<0.1	<0.1
Gross beta	4.5	13	10

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (see figure 6).

[b] The concentrations at mile 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

ND, none was detected.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 15 in terms of mR/hr.

Discussion of data

The average air contamination level for gross beta activity, as shown by the continuous air monitoring filter data (table 11), for both the immediate and remote environs of the plants (figures 1 and 2) was less than 1 percent of

Table 15. External gamma radiation levels, Oak Ridge area July–December 1965

Location	Average dose rates (mR/hr)
Solway Gate	0.010
Y-12, East Portal	0.010
Newcomb Road	0.012
Gallaher Gate	0.012
White Wing Gate	0.011
Average	0.011

the AEC standard for populations in the neighborhood of a controlled area. This value is approximately one-third of that for the first half of 1965 and is no higher than the average of those measured in other areas of the United States and reported by the U.S. Public Health Service Radiation Surveillance Network for this period.

The average air contamination levels for gross alpha activity, as shown by the continuous air monitoring filter data (table 12), for the immediate and remote environs of the plants were 0.40 percent and 0.15 percent, respectively, of the AEC standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.11 pCi/m^3. This is approximately 0.011 percent of the AEC standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge Area were 6.1 pCi/liter and 5.9 pCi/liter, respectively. These values fall within the limits of FRC Range I if one assumes the average intake per individual to be 1 liter of milk per day.

The average concentration of strontium-90 in raw milk for both the immediate and remote environs of the controlled area was 23 pCi/liter. This level falls within FRC Range II for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tennessee) were 13 pCi/liter and 10 pCi/liter, respectively. These values are 0.34 percent and 0.50 percent of the weighted average AEC standards. The average concentration of transuranic alpha emitters in the Clinch River at mile 20.8 was 0.04 pCi/liter which is approximately 0.001 percent of the weighted average AEC standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge Area was 0.011 mR/hr, which is approximately the same as that level measured in the early period prior to Oak Ridge operations.

Conclusion

Surveillance of the radioactivity in the Oak Ridge environs indicated that the major part of the radioactivity detected continues to be the result of fallout from weapons testing. While some low-level radioactivity is being released to the environment from plant operations, the resulting concentrations in both the atmosphere and surface streams of the Oak Ridge environment are well below established AEC standards for the neighboring population.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
1962	September 1963
1963	July 1964
January–June 1964	January 1965
July–December 1964	July 1965
January–June 1965	January 1966

Section V. Technical Notes

CESIUM-137 AND STRONTIUM-90 IN A DAIRYLAND ENVIRONMENT

E. R. Wykes[1]

A study was conducted during 1964 and 1965 to obtain information concerning cesium-137 and strontium-90 in milk, soil, root mat, and grasses or hay. The objective was to determine, in these media, (a) the relative abundance of these radionuclides, and (b) the ratios of cesium-137 to strontium-90. Five farms at the Elk River, Minnesota, milkshed were chosen for this study. The area concerned covers approximately 65 square miles, and it was assumed that no geographic variability of fallout distribution existed. Monitoring data indicate that controlled releases by the Rural Cooperative Power Association (RCPA) Elk River Reactor have not contributed detectable amounts of radioactivity to farms surrounding the reactor. General farming practices were similar among the farms; thus, variations that might be induced by different farming practices would be minimal.

The locations of the five farms studied are shown in figure 1. Most of the area is covered by glacial deposits that are primarily loose sand and pebbles. Farm D is located on an old Mississipi River flood plain; but here, as elsewhere in the area, the topsoil contains a considerable amount of fine-to-medium-grained loose quartz sand.

In choosing the farms, four topographical areas were considered: (a) level field, (b) lowland swamp, (c) upland uncultivated pasture, and (d) wooded area used for pasture. All of the farms in the study had at least two, and one farm had four, of these features. The characteristics of the individual farms are shown in table 1.

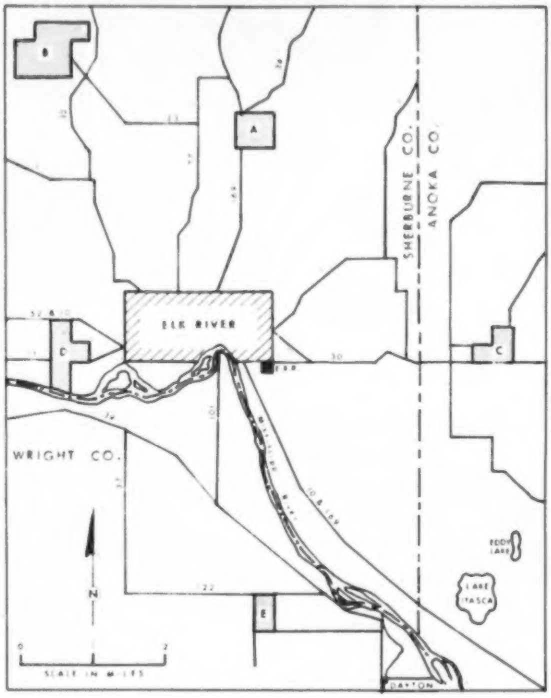

Figure 1. Location of farms

Samples were collected during the 9-day period June 9 through June 17, 1964, and the 11-day period June 15 through June 25, 1965.

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Table 1. Characteristics of five farms in the Elk River, Minnesota, milkshed

Farm code	Type of farm	Geology	Collection point	Description	Feed	Daily production (pounds)	Herd
A	Uncultivated pasture, swamp, cultivated fields	Sandy, rocks and pebbles, small quartz grains in soil	1 2 3	Lowland swamp grass Upland pasture grass Lowland hay field	Summer Silage, Corn fodder, Pasture Winter Corn, Oats, Hay, Meal	550	21 Holsteins
B	Uncultivated pasture, swamp, cultivated fields, woods	Very sandy soil	4 5 6 7	Upland pasture grass Lowland swamp grass Upland alfalfa field Upland forest area	Summer Screening, Silage, Pasture Winter Screening, Silage, Hay, Concentrate	100	35 Holsteins
C	Cultivated fields, swamp, woods	Brown sandy soil	9 10 11	Lowland forest area Lowland hay and alfalfa field Lowland hay field (marsh)	Summer Hay, Silage, Corn Winter Hay, Alfalfa, Corn	950	32 Holsteins
D	Level lowland, cultivated fields, some uncultivated land	River terrace, flood plain, hard soil, considerable quartz	8 15 16	Lowland alfalfa field Lowland alfalfa field Lowland wooded area	Summer Hay, Grain, Screening Winter Silage, Corn, Hay, Screening	800	27 Holsteins
E	Hilly pasture, cultivated fields 3-year-old alfalfa fields	Rolling sandy hills	12 13 14	Upland alfalfa field Upland pasture Lowland marsh area	Summer Pasture, Silage, Hay, Concentrate Winter Silage, Hay, Concentrate	800	40 Jerseys

Sampling procedures

Milk. One-liter samples of raw milk were collected at each farm. These were analyzed for cesium–137 and iodine–131 in five samples collected in 1964, and for cesium–137, iodine–131, and strontium–90 in five samples collected in 1965.

Vegetation. The vegetation consisted of hay, alfalfa, and pasture grasses. Previous studies had indicated that hay contributed the bulk of cesium–137 and strontium–90 intake for cattle, with grain contributing only about one-tenth as much as hay (*1*). All grass and hay samples were from the first spring growth each year and were collected in the vicinity of the soil-sampling sites. The grass and hay samples were analyzed for cesium–137 and strontium–90.

Soils. Sampling sites were selected on the basis of topography and undisturbed ground. Samples were collected only from permanent pastures and fields uncultivated for a minimum of 3 years. At each site, for each year, a total of five surface samples were taken from the corners and center of a 10-foot square, and combined into a composite sample. Subsurface (2 to 6 inches below the surface) sample composites were also taken from the same square. All composited soil samples were analyzed for cesium–137 and strontium–90.

Root mat. The 1964 root mat samples were taken after the vegetation was cut 1 inch above the ground, and consisted of plant root, plant stem, and some decayed vegetation that unavoidably remained on the surface of the soil. However, the greater part of the sample consisted of the live roots of the vegetation. In 1965, all plant stems and decayed vegetation were removed before root mat collection, and all the soil was separated from the samples by hand and by washing in the laboratory. The root mat was composited for each farm and analyzed for cesium–137 and strontium–90.

Laboratory procedures and results

Cesium–137 was determined by gamma spectroscopy. Samples were counted at least 100 minutes with a sodium iodide scintillation crystal and multichannel analyzer.

Strontium–90 determinations were made by radiochemical procedures after suitable preparation of the various types of sample.

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Table 2 shows the results of the cesium-137 analyses in all media except milk. Table 3 shows the results of strontium-90 analyses in the same media, and the cesium-137 to strontium-90 ratios for the averages of these media for all the farms. The concentrations of cesium-137, strontium-90, and iodine-131 in the milk samples are presented in table 4.

Table 2. Cesium-137 in root mat, grass, and soil from permanent pastures and fields, 1964 and 1965

Collection point	Concentrations in pCi/kg							
	Root mat		Grass		Surface soil		Subsoil	
	1964	1965	1964	1965	1964	1965	1964	1965
Farm A	7,700	4,900						
1			3,000	1,400	4,100	2,300	350	120
2			2,800	1,400	1,600	1,600	48	30
3			1,200	5,600	960	850	190	140
Farm B	6,200	15,000						
4			[illegible] 200	4,600	1,600	1,300	50	30
5			21,000	22,000	1,800	2,000	50	40
6			1,400	660	640	1,600	170	140
7			2,600	4,900	490	720	50	30
Farm C	4,200	3,000						
9			1,100	400	2,200	2,000	90	30
10			1,400	460	960	1,500	240	150
11			1,900	340	1,300	1,300	360	150
Farm D	5,800	13,000						
8			1,800	1,400	960	950	220	90
15			2,300	810	690	1,100	170	250
16			2,800	860	960	1,000	70	10
Farm E	4,400	4,800						
12			1,400	530	800	1,400	240	330
13			4,200	720	1,700	1,700	240	120
14			680	330	2,100	2,900	580	200
Average	5,700	8,100	3,300	2,900	1,400	1,500	200	120

Table 3. Strontium-90 in root mat, grass, and soil from permanent pastures and fields, 1964 and 1965

Collection point	Concentrations in pCi/kh							
	Root mat		Grass		Surface soil		Subsoil	
	1964	1965	1964	1965	1964	1965	1964	1965
Farm A	3,300	2,600						
1			5,800	1,400	1,900	880	150	250
2			3,200	2,300	640	680	10	71
3			1,400	1,200	400	380	160	94
Farm B	3,700	5,600						
4			3,200	3,500	1,000	700	8	8
5			6,800	3,300	240	1,200	22	74
6			2,000	2,300	420	720	66	74
7			3,000	2,300	150	220	8	10
Farm C	2,800	1,900						
9			1,100	1,300	870	990	66	52
10			1,700	2,100	630	770	97	120
11			2,100	1,000	920	590	140	110
Farm D	4,300	5,800						
8			2,200	1,800	540	400	82	70
15			3,100	550	510	700	100	150
16			1,300	930	440	50	28	63
Farm E	2,600	1,900						
12			2,300	2,100	480	550	81	130
13			4,200	1,600	770	500	60	70
14			610	480	600	390	180	54
Average	3,300	3,600	2,800	1,800	650	640	80	90
Ratio of averages ^{137}Cs/^{90}Sr	1.73	2.25	1.18	1.56	2.16	2.34	2.5	1.33

Table 4. Radionuclides in raw milk from five Elk River farms, 1964 and 1965

Collection point	Cesium-137 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)	
	1964	1965	1964	1965	June 17, 1964	June 24, 1965
Farm A	150	63	No analyses	24	ND	11
Farm B	260	270		47	ND	14
Farm C	110	97		21	12	ND
Farm D	150	100		13	ND	24
Farm E	180	89		17	ND	11
Average	170	120		24	ND	15

ND, not detectable, or less than 10 pCi/liter.

Conclusions

In the dairyland area considered here, the root mat contained more of the fallout radionuclides cesium-137 and strontium-90 per unit mass than did the other media studied.

The ratio of cesium-137 to strontium-90 between sample media varied between 1.18 and 2.50.

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REFERENCE

(*1*) MINNESOTA DEPARTMENT OF HEALTH and UNIVERSITY OF MINNESOTA. Factors influencing strontium-90 in milk from the Brainerd, Minnesota, milkshed, PHS Publication No. 999-R-1. U.S. Department of Health, Education, and Welfare, PHS, Division of Radiological Health (December 1962).

REPORTED NUCLEAR DETONATIONS, AUGUST 1966

One U.S. nuclear test at the Nevada Test Site was announced by the Atomic Energy Commission in August 1966. This was a low-yield test conducted underground on August 10.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

POLONIUM-210 IN TOBACCO, CIGARETTE SMOKE, AND SELECTED HUMAN ORGANS. *E. Ferri* and *E. J. Baratta. Radiological Health Data and Reports, Vol. 7, September 1966, p. 485–488.*

By means of a "smoking machine" to simulate actual smoking, it was found that polonium-210 concentrations in inhaled tobacco smoke accounted for about 11 to 30 percent of that found in the total product, depending on the type of filter used. Analyses of human tissues indicated that the lung, blood, and liver, in that order, of smokers contained more polonium-210 than the corresponding organs of nonsmokers.

KEY WORDS: blood, bone, cigarettes, heart, human tissues, lead-210, liver, lung, muscle, polonium-210, radionuclides, radium—226, smoking machine, spleen.

MAINE'S EXPERIENCE WITH A STATE-OPERATED PERSONNEL MONITORING PROGRAM FOR RADIATION WORKERS. *J. W. Fuller. Radiological Health Data and Reports, Vol. 7, September 1966, pp. 489–492.*

In a 10-year program of monitoring exposures of radiation workers, Maine's Department of Health and Welfare found increasing acceptance of its free film badge services. Results of findings are outlined. Examination of over 5,000 film badges in 1965 indicated that exposure of the great majority of individuals was relatively low. Periodic radiological health surveys of installations that used independent film badge services indicated that no exposures to individual workers exceeded 100 milliroentgens per week.

KEY WORDS: exposure, film badge, Maine, radiation, radionuclides, X-ray.

☆ U.S. Government Printing Office: 1966—800/3

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